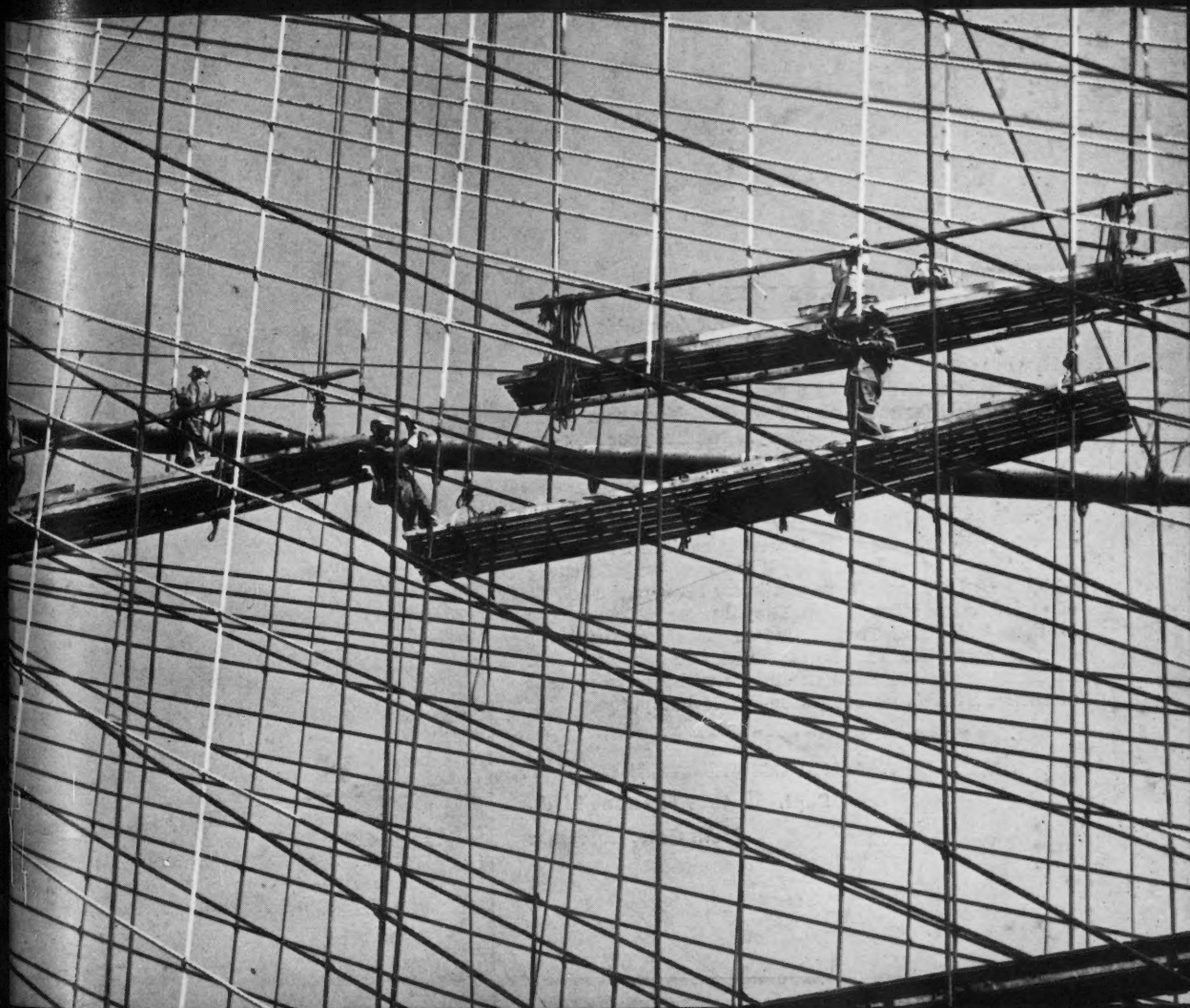


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Official Publication of  
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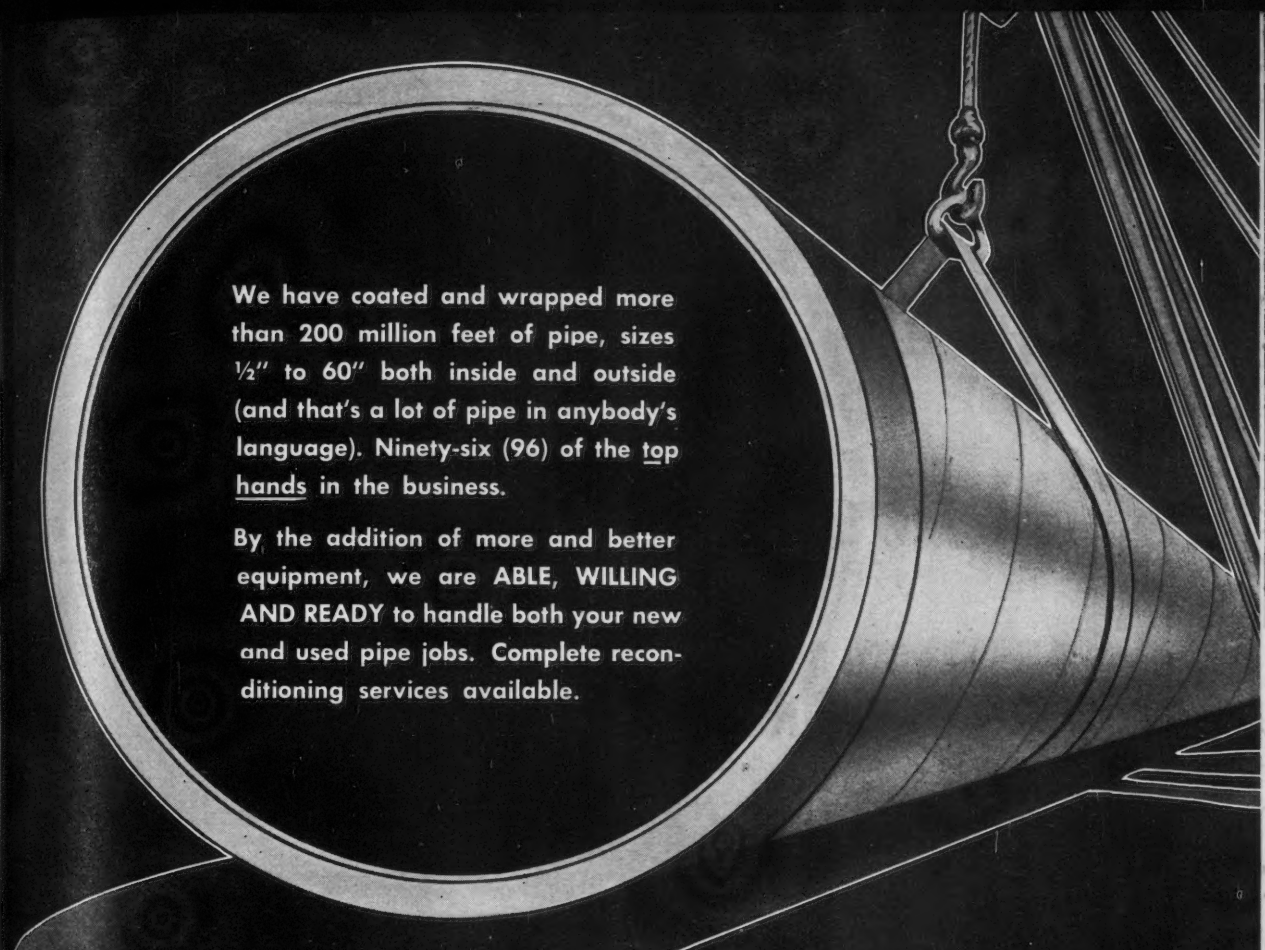


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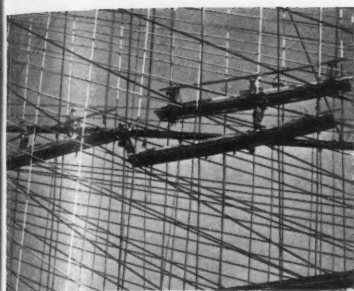
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Entered as second class matter October 31, 1946, at the Post Office at Houston, Texas, under the act of March 3, 1879.

*CORROSION* is Indexed Regularly by Engineering Index.

# Corrosion

devoted entirely to

## CORROSION

## Research and Control

Published monthly as its official journal, by the National Association of Corrosion Engineers, Inc., at Houston, Texas, U. S. A., to provide a permanent record of progress in the control of corrosion as described in papers prepared for the Association and from other sources.

Vol. 5

MAY, 1949

No. 5



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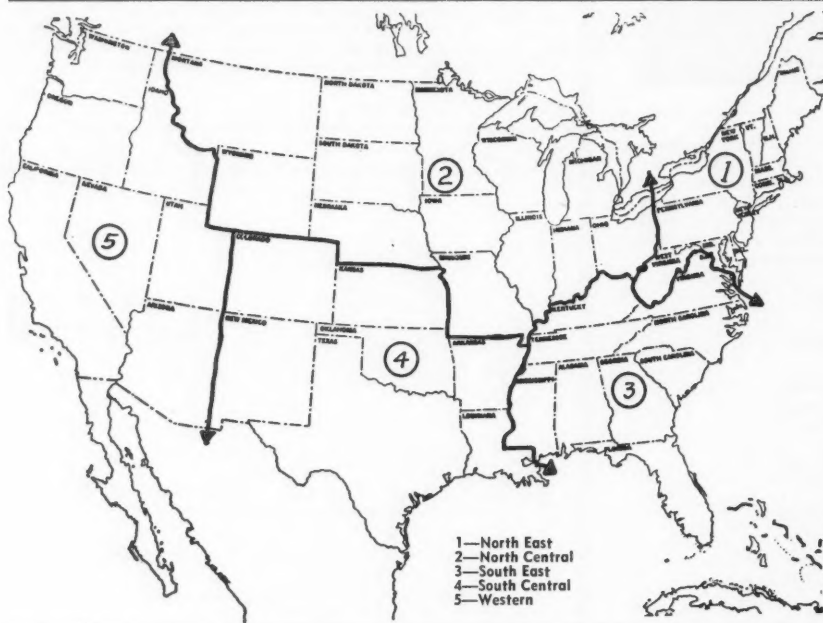
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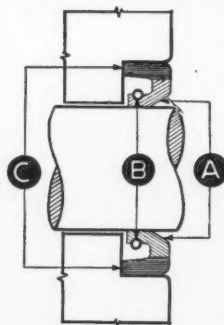
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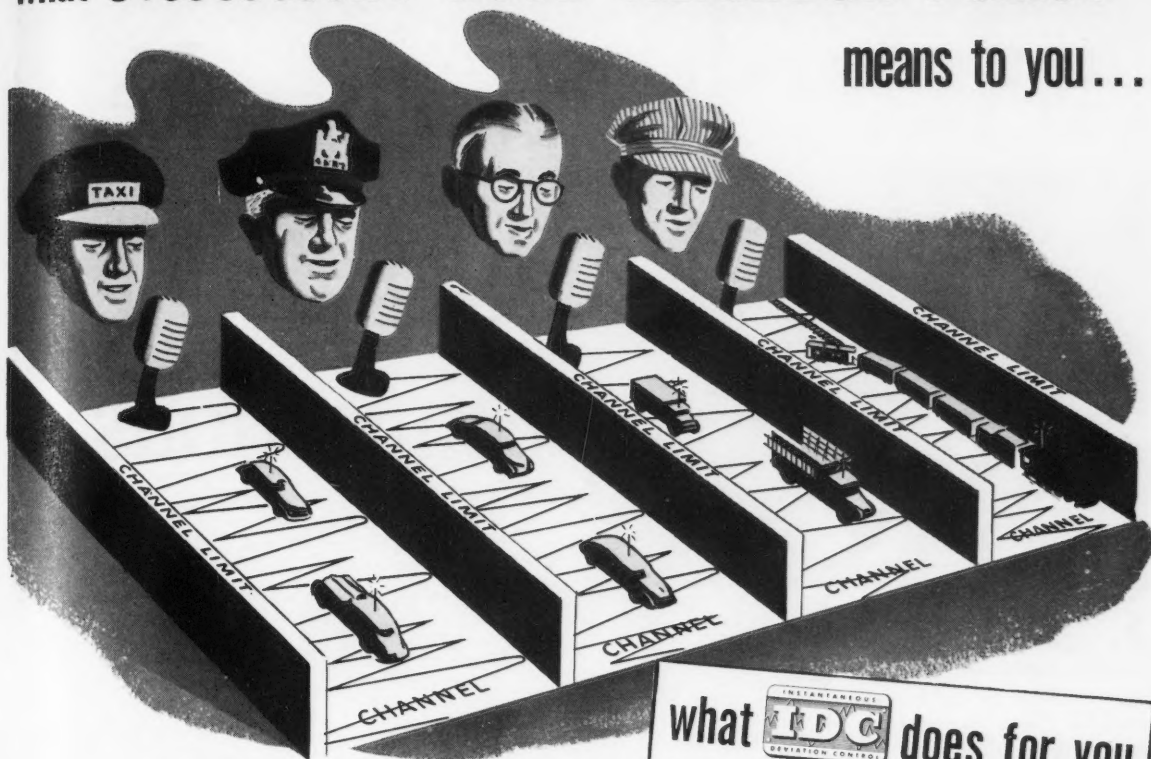
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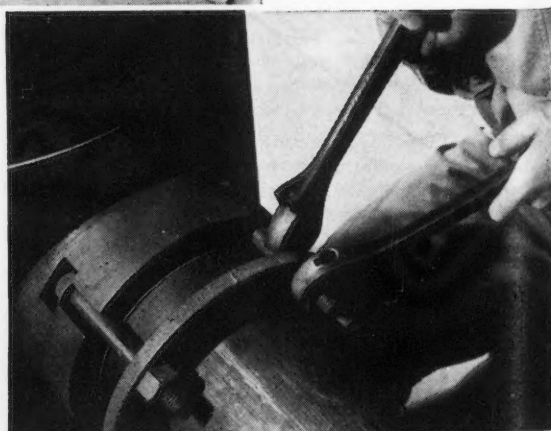
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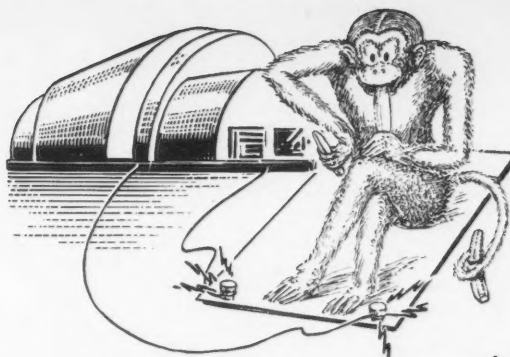


**3.** "Karbate" pipe being joined to gas inlet of a "Karbate" absorption tower by means of strong "Type V" flanged connection. Note flat place on bolt in foreground. This provides purchase for the second wrench to assure tightness in joint.

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## Technical Committee Activities

### Extensive New Fields of Inquiry Are Considered by T. P. Committee 1

By W. F. ROGERS, *Chairman\**

Technical Practices Committee No. 1 was organized in 1944 to study the corrosion rate of metals and alloys in condensate well service. The committee was formed of metallurgists, manufacturers of metals and alloys and oil producers. The joint effort of these men has resulted in an unusually thorough study of the corrosion resistance of 32 metals and alloys. These materials range in composition from the API grades of tubular materials to the high percentage nickel and chromium alloys. The preparation of the report has required considerable time and effort.

Not only have weight and pit depth measurements been made on 895 specimens but the results have been analyzed by statistical means to aid the interpretation of the data. While the results of the work are known to most students of the problem, the report has not been made public because the committee has not had an opportunity to pass final judgment on it. It is hoped and expected that the next 30 days will see the conclusion of this phase of the work, after which the full report will be available for publication by the Association. The committee feels proud of its accomplishments thus far.

Faced with the conclusion of the testing of alloys in condensate well service, the committee began in 1948 to look for added fields in which it could be of service. The logical step was to broaden the scope of the committee work to include the corrosion of oil as well as gas wells. After the St. Louis meeting of April, 1948, the committee petitioned the board of directors through the Technical Practices Committee to increase its activities. This has been done and the committee name has been changed to Technical Practices Committee No. 1, Corrosion of Oil Well and Gas Well Equipment, in order to show its present

activities. This opens a field which offers a fruitful harvest to energetic workers. The causes of oil well subsurface corrosion have never been properly determined and are well worth careful study. Some progress in down-the-hole treatment has been made through the use of wetting agents or other film forming treatments. Other and perhaps more economic treatments may be developed when the governing factors of this corrosive reaction are known.

A study of the magnitude of galvanic action through the coupling of dissimilar metals in both oil and gas wells should be made. There is considerable discussion about the relative importance of this phenomena but little is actually known. The problem of whether to insulate flow lines from well heads is a troublesome one. Most wells have a small amount of current entering them from the flow line but the industry is as much at loss now as it was 20 years ago as to whether the use of insulating flanges would pay dividends.

Laboratory research projects at foundations and universities might be sponsored by the committee. Such subjects as the importance of oxygen in increasing the corrosion rate of sulfide fluids; why are some sulfide waters corrosive and others non-corrosive; why are oil well brines more corrosive than brines from salt wells, all could be studied in the laboratory. The institution of research fellowships on such industry-wide problems will repay the committee many times.

In short, we believe the oil and gas well committee is off to a good start and it is hoped that the future will bring to it many successes.

\* Gulf Oil Corp., Houston, Texas

# THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

(a) to promote scientific research in determining the causes of corrosion and methods of its control with respect to theory and practice.

(b) to provide a means of exchange of knowledge and ideas among those individuals actively engaged in the control of corrosion.

(c) to promote methods of control of corrosion.

(d) to promote standardization of terminology, methods, equipment and design in the development of methods of corrosion control.

(e) to foster cooperation between individual owners of metallic structures in the solution of their joint corrosion problems.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers are nominated by (1) the Board of Directors, or (2) a quorum of at least 25 members, and elected by the membership.

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Figure 2—General corrosion in atmospheric condenser.

# Crude Still Overhead System Corrosion\*

By A. F. BLUMER\*

## Introduction

CORROSION HAS always been a problem in the refining industry and as the industry has enlarged and employed the use of corrosive chemicals, corrosion problems have become more numerous and more complex. It is the purpose of this paper to limit the discussion of corrosion to that occurring in the overhead equipment of the crude distillation units.

The Baton Rouge Refinery, of the Esso Standard Oil Company, at the present time is operating seven crude distillation units, processing approximately 215,000 barrels of crude per day. Contemplated new construction is intended to increase daily crude capacity to 250,000 barrels.

Crude distillation units have experienced corrosion, particularly in overhead equipment and this corrosion has become progressively more acute due to forcing increased amounts of feed through the units and because of processing crudes which have become less sweet and more salty. In the early days of crude distillation, equipment life was not limiting, but more recently in a few acute cases equipment life has limited the run lengths. Cost of equipment replacement is high, but when equipment life limits the run lengths the value of loss of production vastly overshadows the equipment cost. With corrosion constantly becoming more acute and having arrived at a point where run lengths are being limited by equip-

ment life, it now has become extremely important that solutions to corrosion problems be sought and found.

## General Corrosion

Most common form of corrosion is general corrosion, which is characterized by chemical reaction which proceeds more or less uniformly over the entire exposed surface. General corrosion in the overhead equipment of the distillation units is attributed to acidic constituents of the overhead streams. These are principally hydrogen chloride, hydrogen sulphide and possibly carbon dioxide. Corrosion by these media can occur only in the presence of water vapor and oxygen and is accelerated by the presence of oxygen. All these materials contributing to general

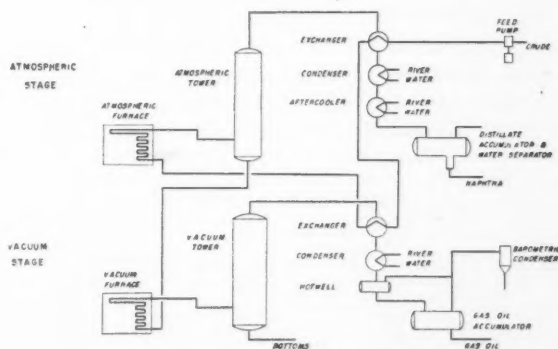


Figure 1—Two stage crude distillation unit.

\* Adapted from a report by F. G. Thatcher and A. H. Tuthill, Esso Standard Oil Company, Baton Rouge, La.

\* Presented at a Meeting of South Central Region, NACE, Tulsa Okla., Sept. 20, 1948.

\* Esso Standard Oil Co., Equipment Inspection Department, Louisiana Division, Baton Rouge, La.

corrosion are known to exist in the overhead streams of the distillation unit:

Figure 1 is a flow diagram of a typical two-stage crude distillation unit. Single stage units are similar but are comprised of only the atmospheric side. This figure will serve to locate and show the function of the items of equipment discussed herein. Referring to this figure, general corrosion is encountered as follows:

1. General slight corrosion in the atmospheric and vacuum vapor lines. The service life of carbon steel is satisfactory, however, and this corrosion is not considered serious.
2. Corrosion in the form of graphitization in the cast iron atmospheric exchanger and condenser shells. This corrosion has been increasing constantly as evidenced by a fifteen-year service life for the original shells and a two-year life expectancy for the replacement shells. Recently constructed distillation units are provided with Monel shells in this location.
3. Continued corrosion of admiral tube bundles in the atmospheric and vacuum exchangers and condensers.
4. Rapid corrosion of atmospheric distillate rundown piping. In some cases, corrosion failures in this piping have limited the run lengths and this has led to the use of Monel-lined pipe. The lined pipe gives good service life, but is not completely satisfactory.
5. Corrosion in the Monel-clad aftercooler shells. This is localized at the shell inlet and is probably a combined erosion-corrosion effect. Monel patches have given good service.
6. Corrosion in the distillate accumulators and water separators. Replacement of parts or complete vessels has been necessary, and partial Monel liners have been installed.
7. Corrosion in the steel vacuum condenser shells. This has necessitated renewal of the bottom half of the condensers and the installation of partial Monel liners after ten to twelve years service.
8. Corrosion in the form of graphitization in the cast iron hot wells below the vacuum condensers. This required replacement of the cast iron hot wells with Monel-lined steel vessels after ten to twelve years service.
9. Corrosion in the barometric condensers requiring the installation of steel patches.

### Hydrogen Chloride

Hydrogen chloride in the distillation unit overhead stream is attributed to decomposition of salts introduced in crude feed. Crude contains varying amounts of salts, predominantly sodium chloride, magnesium



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chloride, calcium chloride and sodium bicarbonate, and the respective ratio of these salts is approximately in the same order as salts contained in sea water. The ratio of salts in sea water varies according to location but is in the approximate order shown in Table I. Hydrogen chloride is believed to come from decomposition of magnesium chloride and possibly calcium chloride which are the most unstable of these salts.

Crudes processed in the Baton Rouge Refinery are principally Louisiana and Mississippi crudes. Table II shows average salt content for a 14-month period of the ten principal crudes processed. Salt content is seen to vary per thousand barrels from 12 lb. to 63.5 lb. Actually from month to month, the salt content of a single crude varies through a wide range and generally follows the pattern of increasing during winter months. This is illustrated in Table III,

where the monthly salt contents of a typical crude are listed for 14 months. In this crude, the monthly salt content varied per thousand barrels from 4 lb. to 212 lb., an average for the period of 33 lb. per thousand barrels. In determining salt content of crude receipts, crudes are analyzed for chloride ions and these are reported as totally sodium chloride, whereas actually the chlorides are magnesium chloride, calcium chloride and potassium chloride, as well as sodium chloride.

It is believed the decomposition of magnesium and possibly calcium chloride may begin in the preheat exchangers at a temperature of about 245° F. The formation of hydrogen chloride probably continues by progressive breakdown of the salts through the

Table II—Salt Content of Crudes  
(Average for 14 Month Period, Numbers Show Salt Lb./1000 Bbl.)

Crude A.....	33.0	Crude F.....	15.6
Crude B.....	26.8	Crude G.....	8.3
Crude C.....	63.5	Crude H.....	18.6
Crude D.....	12.0	Crude I.....	14.6
Crude E.....	47.8	Crude J.....	51.5

Table III—Variations in Salt Content  
Crude A  
(Figures give salt in Lb./1000 Bbl.)

Month	1946	1947	
November	14	June	21
December	4	July	23
1947		August	16
January	212	September	16
February	18	October	14
March	29	November	14
April	16	December	35
May	18	1948	
		January	33

Table I—Salts in Sea Water

Salt	Weight Percent of Total Salt
Sodium Chloride.....	68.129
Magnesium Chloride.....	14.420
Sodium Sulphate.....	11.350
Calcium Chloride.....	3.198
Potassium Chloride.....	1.925
Sodium Bicarbonate.....	.557
Potassium Bromide.....	.278

atmospheric fired coils, atmospheric tower bottoms, vacuum fired coils, and vacuum tower bottoms.

Steam is introduced in both the atmospheric and vacuum towers for stripping purposes and furnishes the water vapor necessary for corrosion by hydrogen chloride to occur.

Unless tower top temperature drops below 230° F. (and this seldom occurs) the temperature remains above the dew point of water until the overhead stream enters the exchanger or condenser. Corrosion by hydrogen chloride will begin where the water first condenses and will tend to be localized at the point where the water condensation reaches an appreciable quantity. It has been found, in general, that the most accelerated corrosion attributed to hydrogen chloride will be localized in the upper section of the condenser bundle. This is illustrated in Figure 2 where holes are clearly visible in the tubes in the upper pass. In this particular bundle, very little corrosion was experienced in the tubes below the top pass.

Due to variations in process operations, tower top temperatures may be altered and the dew point of water reached in other locations besides the top of the condenser bundle. Therefore, this somewhat localized accelerated corrosion by hydrogen chloride may not always occur at the same location. In general, however, it has been found it will most consistently occur in the top portion of the condenser bundle.

Decomposition of the salts will occur in the vacuum fired coil and bottom portion of the vacuum tower so that a similar condition occurs in the vacuum overhead equipment. In general, corrosion follows the same pattern occurring in accelerated form in the somewhat localized area where appreciable quantities of water are condensed and in general will occur in the top portion of the condenser bundle.

#### Hydrogen Sulphide

Sulphur is present in the crudes as free sulphur, hydrogen sulphide, mercaptans and organic sulphur compounds. The Baton Rouge Refinery has been fortunate in having available a large quantity of relatively sweet crudes. Table IV shows spot sulphur content during approximately two-year receipts of the ten principal crudes processed. It will be noted that in eight of these, sulphur content varied from 0.11 percent to 0.49 percent, and these would be considered sweet crudes. Two crudes processed show 2.13 percent and 2.31 percent sulphur, respectively and these crudes are the source of many corrosion problems.

Hydrogen sulphide is introduced in the crude feed as a free agent. Further, some of the organic sulphur compounds are broken down or cracked in the atmospheric and vacuum fired coils and the bottom of the

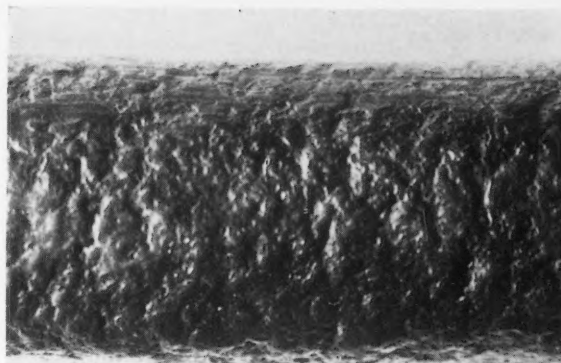


Figure 3—Alligator pattern of sulphide corrosion.

atmospheric and vacuum towers where high temperatures exist. Decomposition of these organic sulphur compounds results in the formation of additional hydrogen sulphide. Corrosion in the fired coils and in the lower part of the atmospheric and vacuum towers usually is attributed to sulphides. Hydrogen sulphide introduced in the crude together with that formed by the decomposition of organic sulphur compounds passes overhead and contributes to the general corrosion in overhead equipment. It has been found that temperature plays an important part in sulphide corrosion and usually a temperature in excess of 500° F. is necessary for sulphide corrosion to occur at an accelerated rate. At the low temperatures encountered in the distillation unit overhead equipment, sulphide corrosion will occur, but generally not at a rate considered serious.

Sulphide corrosion is exhibited in admiralty exchanger and condenser tubes by a typical "alligator" pattern. This "alligator" pattern is shown in Figure 3.

#### Carbon Dioxide

The crudes processed probably contain sodium bicarbonate. The crudes have not been analyzed for this compound, but it is logical to assume they are present and exist in a quantity dependent upon the salt content of the crude and in the same ratio as sodium bicarbonate to sodium chloride in sea water. In general, the ratio of these compounds in sea water will be approximately 1 percent. On this basis sodium bicarbonate in the crude would be less than 0.5 lb. per thousand barrels.

Distillation temperatures are believed to be sufficient at least to decompose partially the sodium bicarbonate and will cause production of carbon dioxide. Carbon dioxide is carried overhead in the distillation unit and will unite with water to form carbonic acid at the point where appreciable quantities of water have been condensed. Carbonic acid has been found to be corrosive to steel; however, considering the quantities of sodium bicarbonate introduced in the crudes and assuming only partial decomposition of the bicarbonate, carbonic acid produced probably is minutely small and corrosion due to this acidic constituent would be negligible.

Table IV—Sulphur Content of Crudes  
(Average of spot checks during 24-month period. Figures are sulphur weight percent)

Crude A.....	0.16	Crude F.....	0.17
Crude B.....	0.21	Crude G.....	2.13
Crude C.....	0.11	Crude H.....	0.27
Crude D.....	0.49	Crude I.....	2.31
Crude E.....	0.29	Crude J.....	0.19



## Combatting General Corrosion

### *Crude Desalting*

The Baton Rouge Refinery for many years has appreciated the importance of crude salt content. One technical group was assigned to study crude production in an effort to bring about a reduction in salt content. This has brought about cooperation between the refinery and crude producers in developing improved methods of chemical desalting and settling in the field. Crude receipts are analyzed constantly for salt content. This control is designed to make producers more acutely aware of the importance of salt content and has effected an improvement in crude receipts in this regard.

Studies also have been instituted into the desirability and economics of additional desalting in the refinery. It is anticipated that future crude receipts will tend toward increased salt content. Some measure of salt reduction is accomplished by settling in the crude storage tanks. In addition, installation of desalting equipment on the crude feed to one of the distillation units is contemplated. This equipment, intended to reduce the salt content to 15 lb. per thousand barrels or lower, has been justified on the basis of increased service factor in that plugging of furnace tubes results from deposition of salts, at least partially, and should be eliminated by proper desalting, and also on the basis that corrosion will be reduced, thereby reducing maintenance cost and improving general unit service factors.

Results obtained by this initial installation of desalting equipment will be followed closely to determine the desirability of extending the practice to other distillation units.

### *Sulphide Removal*

Sulphur in the crude is found as free sulphur, hydrogen sulphide and organic sulphur compounds. Hydrogen sulphide can be removed readily and it has been suggested it be removed in storage tanks by contacting with an alkaline solution. Preliminary laboratory results indicate that addition of 10 percent sodium carbonate to sour distillates results in a marked reduction in the corrosiveness of the crude. Sodium carbonate, if added to the crude before entering the storage tanks, could effectively reduce the hydrogen sulphide content. Although hydrogen sulphide is removed from the crude before it is charged to distillation units, organic sulphur compounds break down during processing to form additional hydrogen sulphide and this still may be a source of considerable sulphide corrosion. Organic sulphur compounds cannot be removed readily and when these compounds are subjected to the temperatures existing in the furnaces and in the tower bottoms they will break down progressively, releasing additional hydrogen sulphide.

Early experience with caustic injection before the feed pumps indicated hydrogen sulphide was converted to stable sodium sulphide which was drawn off in the tower bottoms and thereby reduced the amount of hydrogen sulphide carried overhead in distillation equipment.

Although caustic embrittlement of furnace tubes has not been experienced through the injection of caustic soda, it is considered that this is a distinct possibility with the metal temperatures encountered. For this reason, the use of sodium carbonate for hydrogen sulphide removal at any point ahead of the furnace is preferred at the Baton Rouge Refinery.

### *Neutralizing Acidic Constituents*

As early as 1934 the corrosion in the distillation unit overhead equipment had become of sufficient magnitude to cause initiation of corrective measures. At this time, caustic soda was injected into the crude before the feed pumps and subsequently but not simultaneously into the atmospheric overhead streams between the exchangers and condensers. These two methods of caustic injection were carried on for several years during which they were studied to determine their relative merits.

Caustic injection before the feed pumps was believed to contribute to the plugging of the furnace tubes by the deposition of salt compounds and in some cases actually was considered to limit the run length. For this reason, caustic injection between the atmospheric exchanger and condenser was preferred. It also was found that with caustic injection, service life of condenser tube bundles was reduced approximately one-third. This was attributed to poor distribution of the caustic solution in the vapor stream allowing segregation of alkaline solutions in sufficient strength to cause corrosion of admiralty. Injection of caustic after the exchanger also was found to contribute to plugging of the condenser bundle by the deposition of dry caustic soda.

During this period, and notwithstanding the adverse effects mentioned, analysis of the water draw-off indicated a reduction of total metal content. This would indicate total corrosion in the overhead equipment was reduced, but caustic injection at the same time had created accelerated localized corrosion which shortened the tube bundle life. Therefore, it was believed that if better distribution could be achieved, the service life of the overhead equipment could be improved.

By 1938, caustic was being injected regularly into the atmospheric overhead stream between the exchanger and condenser on all of the then existing distillation units. This practice was continued until 1945 when a comprehensive study was made of experience with caustic injection. This study indicated no improvement in overhead equipment service life had been realized through caustic injection. Actually it is probable that corrosion had been reduced to some extent when it is considered that throughout these years the crudes had become progressively more sour and considerably saltier. It was concluded in this study that the difficulties with caustic injection were as have been outlined already for the earlier studies, and it was recommended that caustic injection be supplanted by ammonia injection into the overhead vapor line near the tower outlet.

Initial installation of ammonia injection was made during 1945 and the results were not too satisfactory

because of inadequate means of control. A second installation made in 1946 was provided with pH recorders on the atmospheric water draw-off stream, and by this means better pH control was achieved. Analysis of the water draw-off on this unit for metal content indicated corrosion had been retarded almost completely. In view of the success with this installation, ammonia injection was extended to all distillation units, but these additional installations were made without pH recorders. Subsequently, ammonia injection also was extended to the vacuum side of the two-stage distillation units. Ammonia injection as outlined is being practiced currently.

The pH of the atmospheric overhead stream is measured at the water draw-off from the distillate accumulator. On those units not equipped with pH recorders this determination is made every two hours using pH paper which is compared with colors on a standard pH color scale. This method is reported to be accurate to 0.5 pH. The pH of the gas-oil overhead of the vacuum tower is determined by using bromthymol blue.

The lower limit of pH has been set at 6 to provide against acidic corrosion of carbon steel and the upper limit has been set at 8 to minimize the possibility of stress corrosion cracking or general corrosion of admiralty. Table V illustrates the relative accuracy of control without recorders as compared with recorders. Without pH recorders, the average range had been 6.0 to 8.5 pH with a minimum of 2 and a maximum of 9.9. Furthermore, there is considerable doubt as to the accuracy of the pH determinations and the accuracy of recording them on run sheets. With recorders, the average range is 7.8 to 8.5 pH with a minimum of 5.7 and a maximum of 9.1. In support of the thesis regarding inaccuracy of pH control without recorders, it is found that on those units where pH recorders have been installed, corrosion difficulties are not serious; whereas on the units not so equipped, corrosion difficulties have continued.

In comparing the relative advantages of the early caustic injection and the more recent ammonia injection, it has been found that no improvement in the service life of equipment was accomplished by ammonia injection over caustic injection where the units were not equipped with pH recorders. It must be kept in mind that the unit throughputs have greatly increased, and the crudes have constantly become more sour and considerably more salty so that the lack of benefits from ammonia injection is not nearly as great as indicated. It is probable corrosion has been retarded more effectively through ammonia injection even though equipment service life has decreased. With caustic injection the average exchanger

bundle life was about  $2\frac{1}{2}$  times the average life with ammonia injection and with caustic injection the average condenser bundle life was about  $1\frac{1}{2}$  times that with ammonia injection. At the present time with ammonia injection average life of the exchanger and condenser bundles is about twelve months.

It has been reported by Bedell<sup>1</sup> of the Socony Vacuum Oil Company that satisfactory control of furnace tube and overhead equipment corrosion has been obtained by the injection of 7 percent aqueous ammonia solution and 24 percent caustic solution into the crude charge. The caustic solution was injected into the crude until a pH of 6.3 was reached in the atmospheric overhead draw-off. Then, ammonia injection to the crude is begun and increased until a pH of 7.5 to 8 was reached.

Camp<sup>2</sup> of the Humble Oil & Refining Company reports that injection of 6 lb. of caustic per thousand barrels of crude into the crude charge combined with ammonia injection in the overhead stream has satisfactorily controlled the corrosion of furnace tubes and overhead equipment on a distillation unit processing West Texas crude. The pH of the overhead stream is controlled by the ammonia injection at 6.5 to 7.0. Plugging of furnace tubes is said not to occur at this ratio of caustic to crude.

Both of these methods of corrosion control have been studied and compared with the system of ammonia injection used at the Baton Rouge Refinery and the conclusion has been reached they definitely have advantages over the system presently used by Esso Standard. Therefore, it has been suggested that partial neutralization of the crude charge, supplemented by final neutralization of the overhead stream is advantageous. An installation of this type is contemplated for further study.

### Selection of Materials

Corrosion in the crude distillation unit overhead systems can, of course, be combatted by selecting materials which will not be corroded at an accelerated rate. This may be done without neutralization practices or may be supplementary to neutralization. The problem of selecting these materials may be complex and frequently each corrosion problem must be treated individually. There may be little relation between conditions which appear to be quite similar. It is not intended that data presented herein should be projected by others who have similar problems, but rather to point out practices in the selection of corrosion resistant materials.

The use of corrosion test spools of the International Nickel Company type probably offers the most reliable method for determining the relative corrosion resistance of materials in corrosive atmospheres. The recommended practices for such tests are covered in detail in ASTM Spec. A224-46, so this discussion will be limited to pointing out added precautions found necessary and certain deviations made at the Baton Rouge Refinery. Practices in the interpretation of results also will be discussed.

It is important the test spool be located so it is exposed properly to conditions responsible for cor-

Table V—Accuracy of pH Control  
(Atmospheric Overhead Stream)

	pH		
	Minimum	Typical Range	Maximum
Ammonia Injection without pH recorder	2.0	6.0—8.5	9.9
Ammonia Injection with pH recorder	5.7	7.8—8.5	9.1

rosion. Crude distillation units offer an example of this in that in the overhead stream a vapor phase and a liquid exist. Since the corrosion occurs principally in the liquid phase, reliable data can be obtained only when the test spool is exposed to the liquid phase. Similarly, other factors which must be considered are phases in mixtures of insoluble liquids, as naphtha and water, velocity effects, turbulence effects, impingement and possibly others. The standard recommends the use of two of each type of sample for better results. While this principle is agreed with, it has been found that in general in refinery corrosion tests, space limitations prohibit following this practice and generally only one sample of each material is used.

Weighing of samples and conversion of weight loss to corrosion in inches penetration per year is done as outlined in the standard. It has been found that calculated corrosion rates cannot be extrapolated to determine corrosion rates of the plant equipment. Actual corrosion rates in general are many times greater than those indicated by the test spools, but the test spools will determine reliably relative corrosion resistance of materials. In Table VI and Table VII are shown results of two typical corrosion tests conducted on the crude distillation units which exemplify the method of selecting the most suitable materials used at Baton Rouge Refinery. After having determined corrosion rates from the test spools, relative prices of the respective materials are procured. These prices are predicated on practical usable units, such as one tube of a certain wall thickness and length, or one sheet of specified dimensions. In general price quotations are received on a per pound basis and must be corrected by the relative densities to convert them to prices per usable unit.

**Table VI—Corrosion Test Spool Data**  
Inlet to Distillate Accumulator and Water Separator  
(Exposure—4 Months)

MATERIAL	Corrosion Inches /Yr.	TUBING		PLATE	
		Relative Price <sup>1</sup> Steel = 1	Economy Constant <sup>3</sup>	Relative Price <sup>2</sup> Steel = 1	Economy Constant <sup>3</sup>
Inconel.....	Nil	14.2	Infinite	11.3	Infinite
Aluminum.....	.0020	1.54	31.4	....	....
Muntz.....	.0063	3.27	4.9	....	....
Stainless 316.....	.0014	15.2	4.7	8.74	8.19
Admiralty.....	.0068	3.39	4.3	....	....
Monel.....	.0036	10.02	2.8	8.54	3.26
Nickel.....	.0036	10.80	2.6	....	....
Super Nickel.....	.0013	4.90	1.8	....	....
Everdur 1010.....	.0216	5.44	0.9	....	....
Stainless 304.....	Corroded Away	....	....	....	....
5 Percent Chrome..	Corroded Away	....	....	....	....
12 Percent Chrome	Corroded Away	....	....	....	....
Carbon Steel.....	Corroded Away	....	....	....	....

<sup>1</sup> Based on quotations for 5,000 lb— $\frac{3}{4}$ " x 14 BWG x 16' long tubes.

<sup>2</sup> Based on quotations for 1,000 lb— $\frac{3}{4}$ " x 36" x 120" plate.

<sup>3</sup> Economy Constant =  $\frac{\text{Corrosion Rate} \times \text{Relative Price} \times 10}{1}$

Considering corrosion rates and prices the relative economics can be determined. For convenience this might be expressed in some such figure as an economy constant. This has been done, defining the economy constant as the reciprocal of ten times the product of the corrosion rate and the relative price. In this method the most economical material carries the highest economy constant.

While it is not intended that derived data be extrapolated to other distillation unit corrosion problems, it might be said that admiralty, muntz, and 70-30 copper-nickel are most favorable as tube materials in the overhead heat exchange equipment. Monel and stainless type 316 are most favorable for plate material for vessel construction and lining materials. Table VI indicates stainless type 316 is preferred to Monel. However, collectively other corrosion test data more consistently indicates that Monel is more economical, and it has been Baton Rouge Refinery's practice to use it in distillation units.

#### Failures In Admiralty Tubes

Aside from corrosion aspects already discussed, failure of admiralty tubes, with which the bundles of the atmospheric and vacuum overhead exchangers and condensers are equipped, constitutes a singular problem of considerable magnitude and probably the most important of the overhead equipment problems. These failures involve general corrosion, special forms of corrosion and mechanical factors; and it is probable that ammonia injection has tended to increase the frequency of the failures.

#### General Corrosion

General corrosion involves a chemical reaction which results in a more or less uniform reduction of the tube wall thickness until the failure occurs. The pattern of this type of corrosion follows comments already made concerning general corrosion, and the corrosion reaches most serious proportions at the point where appreciable quantities of water are con-

**Table VII—Corrosion Test Spool Data**  
Vacuum Overhead Condenser  
(Exposure—15 Months)

MATERIAL	Corrosion Inches /Yr.	TUBING		PLATE	
		Relative Price <sup>1</sup> Steel = 1	Economy Constant <sup>3</sup>	Relative Price <sup>2</sup> Steel = 1	Economy Constant <sup>3</sup>
Admiralty.....	.0003	3.39	98	....	....
Muntz.....	.0005	3.27	61	....	....
Super Nickel.....	.0004	4.90	51	....	....
Monel.....	.0004	10.02	25	8.54	29.25
Inconel.....	.0004	14.2	18	11.3	21.21
Carbon Steel.....	.0092	1.00	11	1.00	11
Stainless 304.....	.0026	8.64	5	6.90	5.58
12 Percent Chrome..	Corroded Away	....	....	....	....
5 Percent Chrome..	Corroded Away	....	....	....	....
		(1)	(3)	(2)	(3)

<sup>1</sup> Based on quotations for 5,000 lb— $\frac{3}{4}$ " x 14 BWG x 16' long tubes.

<sup>2</sup> Based on quotations for 1,000 lb— $\frac{3}{4}$ " x 36" x 120" plate.

<sup>3</sup> Economy Constant =  $\frac{\text{Corrosion Rate} \times \text{Relative Price} \times 10}{1}$



densified initially. In general, all bundles experience general corrosion alone or in combination with special forms of corrosion and mechanical factors. Figure 2 exemplifies general corrosion in an admiralty tube bundle.

#### Dezincification

Admiralty in common with the high zinc brasses has been found to undergo a rapid type of corrosion in hot water and weak acid in which the zinc is removed permanently, leaving a spongy copper layer as a residue or by re-deposition. There are two distinct types of dezincification, one covering large surface areas as illustrated in Figure 4, designated general dezincification, and the other a distinctly localized type as illustrated in Figure 5, designated plug type dezincification.

Failures of the dezincification type have been identified in a number of cases in the tube bundles in the distillation overhead equipment, and it is probable that tube failures in many other bundles not so positively identified were the result of dezincification. It is significant that dezincification can occur in hot water and generally the failures experienced at Baton Rouge Refinery have taken place on the water side of the tube bundles. This significant point is not grasped by many process people who are prone to believe it occurs from weak acid constituents on the process side of the heat exchange equipment. Some cases have been encountered where dezincification has occurred on the process side of the heat exchange equipment, but it is more commonly found on the water side.

It has been found that the addition of arsenic, phosphorous and antimony to admiralty will inhibit corrosion of the dezincification type satisfactorily. Baton Rouge Refinery has used these inhibited tubes for several years and it has been found to combat satisfactorily this type of corrosion. It has been reported that inhibited admiralty will dezincify in hot water and weak acid solutions at higher temperatures, but Baton Rouge Refinery has not identified dezincification as occurring in inhibited admiralty tubes.

This type of corrosion could be eliminated completely by using copper-nickel alloy tubes of the 70-30, 80-20, and 90-10 type and by selecting the proper analysis, tubes of this type can be equally and possibly more resistant to other forms of corrosion than admiralty.

#### Stress Corrosion Cracking

The broad term "stress corrosion" includes any combined effect of stress and corrosion. More commonly where static stresses are involved it is designated stress corrosion, and where cyclic stresses are involved it is designated corrosion fatigue. In general, particularly in the copper alloys, stress corrosion cracking is characterized by intergranular cracks. It is possible, however, for a crack to progress across slip planes or other continuous paths in the crystals and be transcrystalline. Figure 6 illustrates a typical intergranular stress corrosion crack in admiralty.

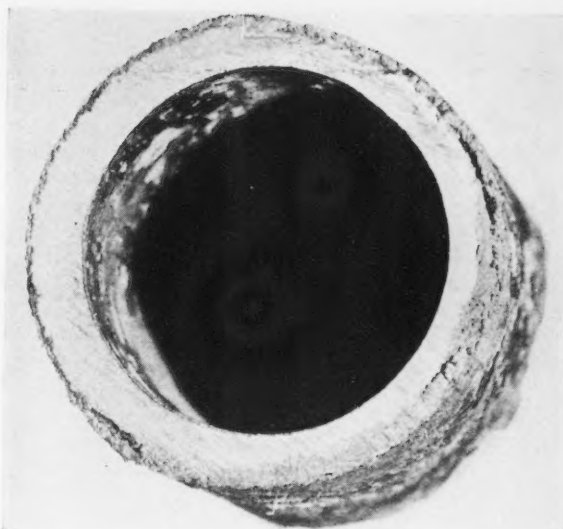


Figure 4—General dezincification.



Figure 5—Plug type dezincification.

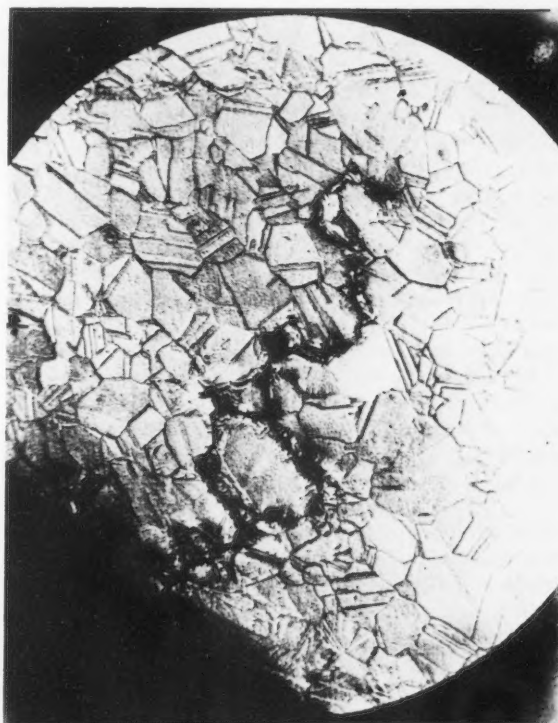


Figure 6—Typical stress corrosion cracking.

Stress corrosion cracking is known to occur in copper-zinc alloys where there are residual internal tensile stresses or external applied tensile stresses, and the material is subjected to specific corrosive media. There are a number of mediums capable of producing stress cracking in admiralty, but those which are in the distillation overhead streams are ammonia and possibly sodium hydroxide.

There is no material inherent to the crude itself which is carried into the overhead system that is capable of producing stress corrosion cracking in admiralty. However, corrosion in the overhead equipment has led to the use of caustic and ammonia injection thereby adding media which can contribute to stress corrosion cracking. It has been experienced at Baton Rouge that caustic injection in the overhead system is not practical but the use of ammonia in combating corrosion will be continued. It is reported that for ammonia to produce stress corrosion cracking, it must be supplemented by water vapor and oxygen and both of these are known to exist in the distillation unit overhead streams.

No control can be exercised over the oxygen and water vapor in the overhead streams. If ammonia were removed or adequately controlled, there could no longer be stress corrosion cracking. Control of ammonia in the overhead stream lends strength to the use of desalting and sulphide removal processes and to the introduction of an alkaline solution ahead of the feed pumps. By these means the corrosive constituents could be reduced and neutralized to a great extent, and the quantities of ammonia necessary would be only that required to neutralize corrosive constituents formed by additional decomposition of salts and sulphides in the furnaces and tower bottoms. The volume of ammonia required would be small in comparison to that presently needed where only ammonia injection is used. It is believed considerable improvement in utilization of the ammonia could be accomplished by the provision of some type of diffuser at the point of injection to create intimate mixing, better contacting, and rapid neutralization. To further minimize the quantities of ammonia injected, the upper limit of the pH control should be set at a level that will minimize stress corrosion cracking, not exceeding pH 8.5 and preferably pH 8. The disadvantage of setting the upper limit too low would be that susceptibility of materials to general corrosion and corrosion fatigue may be increased.

In addition to exposure to a proper corrosive environment, admiralty must have a tensile stress in the order of 12,000 psi or higher for stress corrosion cracking to occur. This stress may be internal residual stress or external applied stress.

As regards internal stresses, admiralty tubes always should be procured in the fully annealed condition. However, rolling the tubes during the assembly of the bundles necessarily must produce stresses exceeding the yield point. Little, if any, control can be exercised over this stress, but difficulties can be avoided if the rolled portion does not project beyond the rear face of the tube sheets.

It is known that assembly of the tube bundles develops longitudinal tensile and compressive stresses

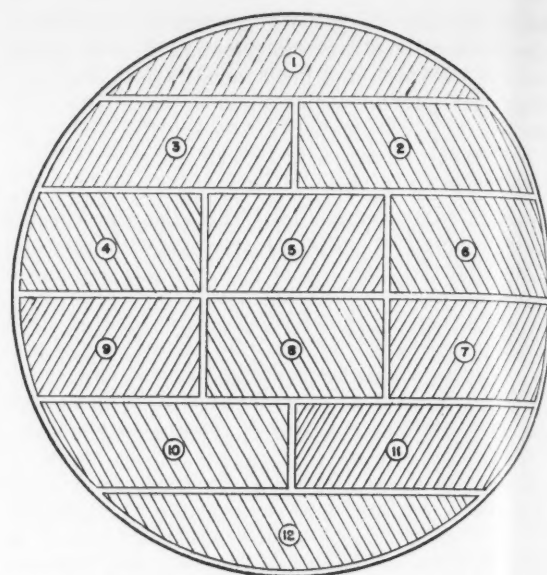


Figure 7—Multiple pass tube bundle. Passes horizontally and vertically adjacent.

in the tubes. The magnitude of these stresses has not been measured but is believed to be dependent upon rolling methods and rolling sequence. In some cases these applied stresses are known to be of a high order as exhibited by the distortion of heavy tube sheets. In one of the more acute cases a 2½-inch dish was created in a 4-foot diameter by 2½ inch thick tube sheet. External applied stresses produced in the assembly of the bundles can be controlled, and here lies the greatest measure of stress control. Magnitude of these stresses will depend upon the rolling methods and the sequence of rolling. These factors have been given serious consideration by the reputable exchanger and condenser manufacturers, and information concerning proper rolling methods and rolling sequence probably can be obtained from these sources. It is beyond the scope of this paper to devote too much attention to this matter except to point out its extreme importance in endeavoring to control stress corrosion cracking.

External or applied stresses also are created in tube bundles by uneven thermal expansion due to temperature differentials across the tube bundles. This is true particularly in multiple pass tube bundles of the type shown in Figure 7. Where the respective passes are both horizontally and vertically adjacent, as in this case, the effect of the floating tube sheet is somewhat nullified and differential expansion creates stresses in the tubes and possibly results in warping in the tube sheets. Tube bundle designs of this type should be avoided, and designs where the passes are adjacent in only one direction should be preferred. By this means some measure of control can be exercised over the magnitude of external applied stresses, and correspondingly over the tendency to stress corrosion cracking.

Stress corrosion cracking may be reduced and possibly eliminated by selection of materials which are less susceptible or completely immune to this

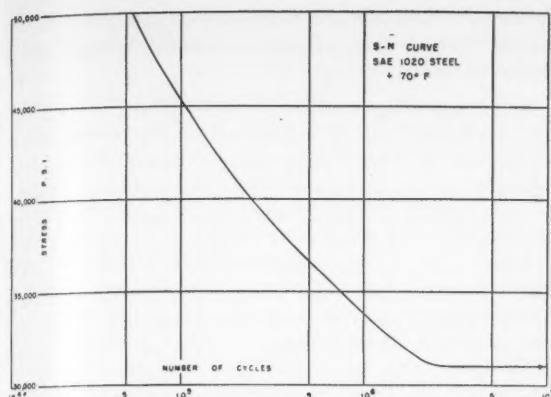


Figure 8—Relation between stress and number of cycles for fatigue failures in carbon steel.

phenomenon in the particular environment. With respect to crude distillation overhead equipment, it is reported that copper-nickel alloys, particularly 70-30 Cu.Ni., are not detrimentally affected under conditions of stress and environment containing ammonia. In view of this Baton Rouge Refinery presently is considering installation of 70-30 Cu.Ni. bundles in the atmospheric overhead equipment to determine their relative merits compared with present admiralty bundles. Monel and stainless type 316, which data indicates may be satisfactory as tubes in this service, would adequately resist stress corrosion cracking, but the cost of these materials may be high as compared with admiralty and 70-30 Cu.Ni.

#### Fatigue and Corrosion Fatigue

It may be difficult to distinguish between fatigue and corrosion fatigue failures to the extent that these could be separately segregated in this discussion. Conditions under which either type of failure can occur are similar, involving cyclic stresses. The difference is that corrosion creates stress raisers and accelerates the progression to failure.

In pure fatigue failures, not involving a corrosive media, a stress exceeding the endurance limit is necessary and a given number of stress reversals correlated with the stress magnitude are required. The relation between the stress and the number of cycles for fatigue failures in carbon steel is shown in Figure 8. This S-N curve is typical of most materials. A pure fatigue failure generally is characterized by a single crack which is predominantly transcrystalline.

Under the combined effect of corrosion and cyclic stresses, corrosion fatigue, fatigue type failures will occur more rapidly than when subjected to cyclic stresses alone. The lowered resistance to fatigue failures is related to the type of pitting induced under conditions of cyclic stress. In unstressed steel, corrosion pits are well rounded and saucer shaped. Under cyclic stresses sharp deep pits are created by the corrosion. These pits act as stress raisers and accelerate the progression of corrosion and cracking. Ultimately the failure proceeds by propagation of the crack and is controlled primarily by stress concen-

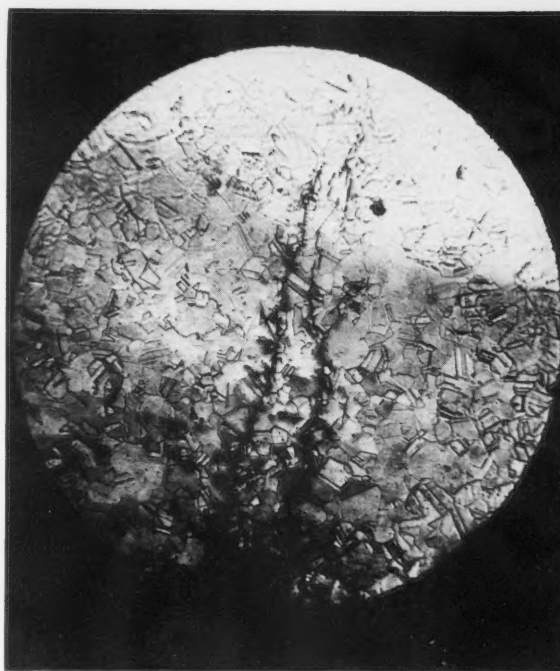


Figure 9—Typical corrosion fatigue failure.

tration effects and the physical properties of the material. Corrosion fatigue failures usually result in several cracks originating at the bottom of corrosion pits and the cracks are predominately transcrystalline. A typical corrosion fatigue failure is illustrated in Figure 9.

It already has been established that corrosive media exist in the distillation unit overhead streams, and these corrosive media certainly can contribute to corrosion fatigue. Corrective measures already discussed for controlling general corrosion can be considered to control effectively the media contributing to corrosion fatigue. As was brought out, some measure of caution must be exercised in setting the pH limit in protecting against stress corrosion. If this limit is set too low, corrosive constituents may not be controlled adequately. Analysis of the various streams for metal content should establish whether or not proper control is being attained.

That cyclic stresses exist has been established by the examination of tubes in which cracking failures have occurred. In many of these a battering effect has been observed where the tubes pass through the intermediate tube sheets, and tubes have been found that are flattened from striking one another. Further substantiating that cyclic stresses play an important part in the failures is the fact that a majority of the cracking failures have occurred at or within 1 inch of the tube sheets, this being the point of maximum flexure in the vibrating tubes.

In order to set up the vibrations from which the cyclic stresses are developed, it is required that there must be first an impulse or initiating force and thereafter there must be a sustaining force. It is probable that high vapor velocities and surges in the overhead



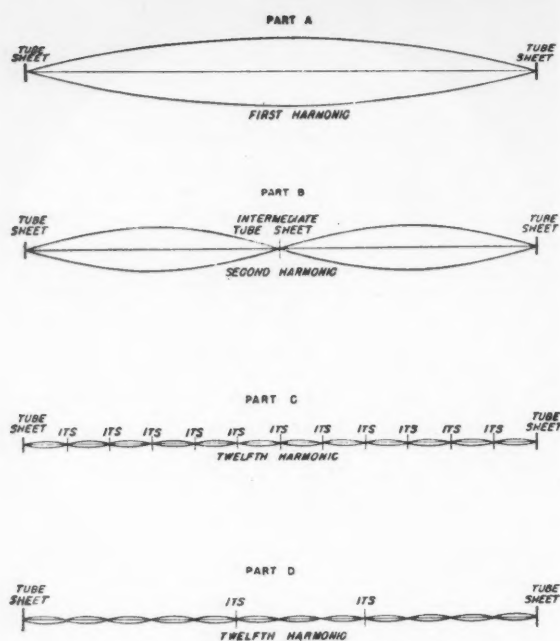


Figure 10—Vibrating systems.

streams furnish forces capable of initiating tube vibrations and of sustaining the vibrations once initiated. The vapor velocities in the atmospheric overhead streams are estimated to be 65 feet to 145 feet per second and in the vacuum overhead streams 29 feet to 32 feet per second. It may be significant that seven cracking failures observed during this study were in atmospheric exchanger bundles and only two failures were in the vacuum exchanger bundles. All these failures were in the top passes where the vapor velocities would have the greatest effect and were around the outer periphery where the tubes were freer to vibrate.

Apparently the use of reciprocating pumps for pumping through the heat exchange equipment can result in forces capable of initiating and sustaining vibrations. For many years Baton Rouge Refinery progressively has replaced reciprocating feed and water pumps on the crude distillation units with centrifugal pumps. At the present time only one unit still is equipped with reciprocating pumps. Six of 13 tube cracking failures studied occurred on this unit and this singularly presents the most serious tube cracking problem.

A cracking failure was observed in one of the atmospheric aftercooler bundles. This bundle was equipped with an inlet splash baffle supported in a cantilever manner. A severe battering, obviously caused by this baffle, was noted in the failed tube and in adjacent tubes. It was believed the baffle had created vibrations in the tubes which ultimately lead to the failure. A new method of support was devised for this baffle so the predisposing conditions could be eliminated.

The refinery contains batteries of compressors in many areas, and vibrations of the general refinery areas conceivably may initiate the tube vibrations.

This is believed to be a remote possibility and certainly there is no correlation with the failures which have occurred.

In a vibrating system a wave of any length can be produced, but to produce a cyclic or repetitive condition the wave must be reflected and sustained. Only those vibrations of which the half wave length is an integral divisor of the fixed lengths will be reflected and vibrations of other wave lengths will dampen out and disappear. Referring to Figure 10, a tube bundle with tube sheets but no intermediate tube support sheets, Part A, would vibrate in the fundamental manner when a node occurred at each tube sheet. The tubes also may vibrate with one or more equally spaced intermediate nodes to produce harmonic overtones. In a tube bundle with one centrally placed intermediate tube sheet, Part B, the tubes will vibrate in the fundamental manner when a node occurs at the tube sheets and at the intermediate tube sheet, or the second harmonic for the complete tube. This process can be continued to any point, as in Part C, where eleven equally spaced tube sheets makes the fundamental vibration the twelfth harmonic of the entire tube. Therefore, the greater the number of intermediate tube sheets the higher becomes the harmonic of the fundamental vibration and the shorter the wave length becomes. Also, the amplitude of the vibration proportionately decreases. The cyclic stresses, being proportional to the amplitude of vibration, can be controlled to a low order by the introduction of a large number of intermediate tube support sheets. If enough intermediate tube support sheets are provided the wave length can be decreased to a point where the rigidity of the tubes will not permit them to vibrate. These factors should be considered in tube bundle designs since they permit an excellent control over corrosion fatigue.

In tube bundles where process requirements prohibit the use of a large number of intermediate tube sheets the same results can be accomplished by using a few oddly spaced intermediate supports. Since node points must occur at each tube sheet and at each intermediate tube support sheet the fundamental wave length must be the lowest common divisor of the respective unsupported lengths. In Part D, two oddly spaced tube sheets where the respective unsupported lengths or 5, 3, and 4 parts of the total length produces a fundamental vibration of the twelfth harmonic, or the same result as the eleven equally spaced support sheets in Part C. The exchanger and condenser tube bundles on Baton Rouge Refinery crude distillation units are single pass or split flow single pass heat exchange equipment, and more than two support sheets cannot be used. This study has led to the use of two oddly spaced tube sheets, with unsupported tube lengths of 6, 5, and 6 parts of the total length. In this bundle the fundamental vibration will be the seventeenth harmonic, and by this means it is believed the cyclic stresses can be reduced to a sufficiently low order to prevent corrosion fatigue failures.

A solution to fatigue and corrosion fatigue failures also may be realized in the selection of materials.

This can be approached from two standpoints, selecting a material which will not corrode or selecting a material of higher endurance strength, i.e., a material that is more resistant to fatigue failures.

The endurance limit of admiralty is 10,000 to 15,000 psi and of carbon steel about 30,000 psi in non-corrosive atmospheres. Corrosion of the surface of the tube develops pits or other surface defects which act as points of stress concentration and reduces the effective endurance limit. Since carbon steel has an initial endurance limit approximately three times that of admiralty, it was probable that a higher effective endurance limit could be realized with carbon steel if the pH was controlled at a point to minimize corrosion of the tube surfaces. Considering this fact, two admiralty exchanger bundles have been replaced with carbon steel bundles in locations where corrosion fatigue failures were most acute, and considerable improvement in the life of these tube bundles has been realized. Also in this connection it is reported that copper-nickel alloys, particularly of the 70-30 Cu.Ni. type, are greatly more resistant to corrosion fatigue than admiralty. Although carbon steel may be satisfactory for exchanger bundles, fouling on the water side would prohibit their use in condenser bundles; and it appears that copper-nickel would be more suitable in condenser service.

### Combined Effects

Conditions favoring all the types of corrosion and mechanical failures discussed are present in the heat exchange equipment in the distillation unit atmospheric and vacuum streams. Ruling out dezincification, which is not likely to figure in the combined effect, it then is apparent that general corrosion, stress corrosion, fatigue and corrosion fatigue can occur in the tubes of this equipment individually or in any combination. Failures may and often do exhibit combinations of these and it is often difficult to identify the failure as predominantly of one type or another.

In seven distillation units there are twenty-two admiralty bundles in the atmospheric overhead streams and twelve admiralty bundles in the vacuum overhead streams. Baton Rouge Refinery records indicate cracking failures occurred in the bundles of seven atmospheric exchangers, three atmospheric condensers, one atmospheric aftercooler, and two vacuum exchangers. Fifteen individual tubes failed by cracking, and eight were in one atmospheric exchanger. Some of these failures have been identified as stress corrosion cracking, others as corrosion fatigue, and one may have been a pure fatigue failure. Several have not been identified positively as one type or another, probably being combinations of several types. Considering that no definite pattern of failures has been established, that failures are often difficult to classify, and that conditions exist which are favorable for any and all of the types of failures to occur it appears the greatest improvement would

be accomplished by controlling the greatest number of all of the factors contributing to the failures.

### Conclusions

As a result of this study of corrosion in crude distillation overhead equipment and summarizing the data, these conclusions have been reached:

1. Chloride corrosion from salt in the crude occurs primarily in the distillation unit overhead equipment and tends to concentrate at the point where water first condenses.
2. Sulphide corrosion is more general throughout the distillation unit equipment and is more accelerated at temperatures in excess of 500° F. At the temperatures in the distillation unit overhead equipment sulphide corrosion will occur but not at a serious rate.
3. Sodium bicarbonate in the crude may decompose to form carbon dioxide which hydrolyzes to carbonic acid and may cause a small amount of corrosion.
4. Removal of the salt compounds and hydrogen sulphide before charging the crude to the distillation units is perhaps the most effective way of reducing corrosion.
5. Acidic constituents formed in the distillation units by the decomposition of salts, sulphur compound, and carbonates can be effectively neutralized by contacting with alkaline solutions.
6. It appears that the most effective means of neutralization would be by partial neutralization of the crude charge, using sodium carbonate, and final neutralization in the overhead stream, using ammonia.
7. pH recorders and possibly pH recorder controllers are essential to proper control of ammonia injection into the overhead stream.
8. Further study may be required to determine the exact limits of pH control, but it appears that a lower limit of pH 6.0 will effectively reduce corrosion and an upper limit of pH 8 will reduce the susceptibility of admiralty tubes to stress corrosion cracking.
9. The use of inhibited admiralty tubes will reduce the possibility of dezincification. The substitution of 70-30 Cu.Ni. tubes will eliminate the dezincification.
10. Admiralty, muntz, and 70-30 Cu.Ni. are most favorable as tube materials in the overhead heat exchange equipment. Monel and stainless type 316 are most favorable for plate materials for vessel construction and lining materials.
11. Stress corrosion cracking in admiralty tubes can be reduced effectively by controlling the pH of the overhead stream within the limits specified. Reduction of external stresses in admiralty tubes through consideration of proper rolling methods, rolling sequence and tube bundle design can reduce the tendency toward stress corrosion cracking in admiralty.
12. Copper-nickel alloys, particularly 70-30 Cu.Ni., are not nearly as susceptible to stress corrosion cracking as admiralty. Monel and stainless type 316 are resistant to stress corrosion cracking in the distillation unit environment, but these do not appear to be economically justified as tube materials.
13. Supplementing the control of general corrosion, fatigue and corrosion fatigue can be combated best by control of the tube vibrations. Tube bundle designs should be such as to provide the maximum number of intermediate tube spacer sheets consistent with process requirements; and where requirements demand only a few tube spacer sheets, these should be oddly spaced along the tube length.
14. The use of carbon steel which has a higher endurance limit than admiralty can be expected to reduce the frequency of corrosion fatigue failures providing chemical control of corrosive media is adequate.
15. For condenser service, fouling probably would prohibit the use of carbon steel, and in this case 70-30 Cu.Ni. which is considerably less susceptible to corrosion fatigue than admiralty could be used to advantage.

### Bibliography

1. H. S. Bedell. "The Use of Chemicals for Retarding Corrosion." Preprint, API Div. of Ref., Mid-Year Meet., May 11, 1948.
2. E. Q. Camp. "Sour Crude Equipment Protection." *Oil and Gas J.*, 46, No. 29, 68-74 (1947) Nov.
- H. H. Uhlig. *Corrosion Handbook*, Pp. 69-96, 569-590.

## DISCUSSION

By E. Q. CAMP\*

Mr. Blumer is to be complimented on the preparation of an excellent paper on crude still corrosion. The paper is well written and the conclusions are sound. It is believed this paper will be well received in the petroleum refining industry.

In the discussion on hydrogen chloride he mentions the salt contents and the variations in the salt contents of the crudes, principally from Louisiana and Mississippi, processed at the Baton Rouge Refinery, but no mention is made of the correlation between salt content and the amount of hydrogen chloride evolved in the distillation steps. It has been our experience on Texas crudes that within normal limits no correlation exists between salt content and the amount of hydrogen chloride evolved upon distillation. For this reason, the salt content of Texas crude is not very good measure of the corrosion to be expected as a result of hydrogen chloride evolution under distillation conditions. The hydrogen chloride evolved under distillation conditions is employed in estimating the corrosiveness of a Texas crude. Standard laboratory tests have been developed for this purpose. It would be interesting to know if Louisiana and Mississippi crudes are similar to Texas crudes with respect to lack of correlation between salt content and amount of hydrogen chloride evolved upon distillation.

In the first paragraph on sulfide removal it is stated that a marked reduction in the corrosiveness of a crude can be effected by contacting the crude with a 10 per cent sodium carbonate solution prior to the distillation step. This reduction in corrosiveness of the crude is attributed to the removal of hydrogen sulfide. It is believed that the removal of hydrogen sulfide from a crude in this manner is only a minor factor in the reduction of the corrosiveness of the crude. It is believed the major factor in reducing the corrosiveness of the crude is a consequence of the effect the sodium carbonate has upon the calcium and magnesium chlorides. It is postulated that the sodium carbonate reacts with the calcium and magnesium chlorides forming sodium chloride and calcium and magnesium hydroxides with a corresponding reduction in the amount of hydrogen chloride evolved in the distillation step. The extent to which the sodium carbonate would react with the calcium and magnesium chlorides would depend upon the extent to which these salts are in solution or would be dissolved by the sodium carbonate solution. Further, if any of the sodium carbonate were to enter the distillation equipment with the crude, it would react with both hydrogen sulfide and hydrogen chloride released in the distillation step.

The possible effect of ammonia on the stress corrosion cracking of copper-bearing alloys is presented. In this connection it might be mentioned that we have never experienced any corrosion of this type in more than fifteen years of injection of ammonia into hydrocarbon vapor lines upstream from exchangers

and condensers that are equipped with copper-bearing alloy tubes. The lack of stress corrosion cracking of the copper-bearing alloys under these conditions is believed to be due to the inhibiting effect of the sulfur and sulfur compounds that are present in the hydrocarbon streams on this type of corrosion. Some information on the inhibiting effect of sulfur and sulfur compounds on corrosion of copper-bearing alloys by ammonia was presented at the 1948 annual meeting of NACE. This paper was published in the August, 1948 issue of *Corrosion*.<sup>1</sup>

It might be mentioned that we have experienced very little if any of the fatigue type failure of condenser and exchanger tubes. It may be that the conditions in our refinery are such that this type of failure would not occur.

## References

1. Camp, E. Q. "Corrosion Prevention in Processing Sour Crudes," *Corrosion*, 4, No. 8, 371-398 (1948) Aug.

## AUTHOR'S REPLY

We are pleased that Mr. Camp has commented on this paper, particularly in view of the fact that his papers on similar subjects were carefully reviewed in conjunction with our study.

In regard to the correlation between the salt content of the crudes and the amount of hydrogen chloride evolved in the distillation steps, we have not conducted investigations along this line. The crudes are analyzed for chlorides, and this is reported totally as sodium chloride. We know that chlorides of magnesium, calcium, and potassium exist along with the sodium chloride, but we have not analyzed the salts for the component parts. While there may not be a correlation between total salt content and hydrogen chloride evolution, it is believed that there may be a correlation between magnesium chloride and possibly calcium chloride content and hydrogen chloride evolution. With a crude from any one source, it is thought that the magnesium chloride content would usually vary directly with the total salt content, and therefore, there might be a correlation between the total salt content and hydrogen chloride evolution. The same relationship, however, would not exist for all types of crudes. If nearly all salt was removed from the crude, as with electrical crude desalting equipment, it is believed that there would be a marked reduction in corrosiveness of the crude. The hydrogen chloride evolved under distillation conditions has not been employed in estimating the corrosiveness of the crude. This is an extremely interesting point, and it is our intention to pursue this line of investigation further.

On sulphide removal, the statements regarding reduction in corrosiveness by the addition of 10 per cent sodium carbonate to sour distillates refer to laboratory tests. In these, sodium carbonate was added to unheated samples which were violently agitated during the tests. Metal specimens were placed in both the liquid and vapor phases of the distillate. Severe corrosion was experienced in both phases of untreated distillates; whereas, when 10 per cent sodium carbonate was added under similar test con-

\* Humble Oil & Refining Company, Baytown, Texas.



ditions, a marked reduction in the corrosion rate of the metal samples in both phases was obtained. A reaction of sodium carbonate with calcium and magnesium chlorides to form calcium and magnesium carbonates probably occurs and may offer a significant reduction in the corrosiveness of the crudes as associated with unit operations. In the test mentioned, however, the reduction in corrosion is believed to be due almost entirely to reduction in hydrogen sulphide, since calcium and magnesium chlorides in themselves are only mildly corrosive as compared with hydrogen sulphide under the conditions of the tests. The removal of hydrogen sulphide, however, offers little advantage, since additional hydrogen sulphide is formed by the decomposition of organic sulphur compounds in the fired coils. The use of sodium carbonate is advantageous, since it lessens the possibility of stress corrosion cracking of furnace tubes. However, its use should be approached with caution, since carbonates entering the fired coil would break down to form carbon dioxide. Carbon dioxide is not considered to be as active a corrosion agent as hydrogen sulphide or hydrogen chloride but does have an appreciable corrosive effect under certain conditions. The use of sodium hydroxide as a neutralizing agent would avoid the formation of carbon dioxide.

Regarding the comments on stress corrosion cracking and fatigue type failures of condenser and exchanger tubes, it was beyond the scope of the paper to thoroughly cover these subjects, since each is a

major subject in itself. Mr. Camp's comments seem to indicate that he has not experienced cracked condenser and exchanger tubes, since in our opinion cracked tubes must be the result of stress corrosion cracking, pure fatigue and corrosion fatigue, these excluding possible material deficiencies. We have found stress corrosion cracking difficult to positively identify, and this is probably due to the fact that it is not encountered in the pure state but is usually in combination with fatigue or corrosion fatigue. We have conducted metallographic studies which we believe indicate stress corrosion cracking and others which indicate fatigue and corrosion fatigue. We have not conducted any investigation concerning the inhibiting effect of sulphur and sulphur compounds; and while we agree that these materials probably do inhibit stress corrosion cracking, they probably effect a reduction in the tendency to crack rather than eliminate the possibility. It is the intent of the paper to point out that certain factors known to exist present the possibility of stress corrosion cracking. Other factors known to exist favor fatigue and corrosion fatigue type failures. These factors often are related and cannot be independently segregated. Since metallographic studies will not positively identify the failures as stress corrosion cracking or fatigue type failures, it is felt that difficulty will be encountered in attempting to segregate the failures as one or another type, and that the greatest improvement is realized by controlling the greatest number of factors which contribute to all types of failures.

## DISCUSSIONS ARE INVITED

Readers who wish to submit written information additive to articles published in CORROSION, or who wish to register differences of opinion with respect to any article are urged to send such discussions to Dr. Paul Bachman, Chairman, NACE Editorial Review Committee, Commercial Solvents Corp., Terre Haute, Indiana. Doctor Bachman will submit such discussions to a member of the review committee, and after review and approval the discussion will be published.

The expression of opinions about or the addition of information to that contained in technical articles will advance the interests of NACE and make CORROSION more valuable to the membership.

# Building Organic Protective Coatings to Special Requirements\*

By K. G. COMPTON\*

A LARGE PROPORTION of the current 800 million dollar annual purchases of paint in the United States is employed as protective coating for metal. While simple pigmented linseed oil maintenance paints constitute a large proportion of this, an increasing volume of products based on synthetic resins combined with drying oils is finding its way into the industrial market because such materials can be "tailored" to suit the user's requirements. Furthermore, many industrial finishes must be capable of rapid cure in order to fit into mass production manufacturing schedules.

Organic coatings largely owe their protective properties to the impervious character of the envelope they provide around the protected metal. Hence the physical properties of a coating are of the greatest importance. These include adherence to the metal, hardness and toughness to withstand impact and scraping, flexibility and the inclusion of environmental factors such as moisture or chemical fumes. In general a proper balance of these physical characteristics is required because they are inter-related to a great extent. Sometimes a compromise must be made for the reason that all of these physical properties (for example, hardness and abrasion resistance), are not compatible in all degrees.

The basic behavior and effect on the physical properties of organic finishes of raw materials generally used in paint formulation work have been well established. The effect of a particular constituent on the properties of a finish can be obtained by various test methods and devices which have been developed and which are described in the literature.<sup>1</sup>

Even though the effect of planned changes in composition may be anticipated from basic knowledge of the raw materials involved, in many cases it may be necessary to adjust composition in steps with an accompanying evaluation of physical properties to get the proper compositional values.

Organic protective coatings frequently are classified as paints, varnishes and enamels, lacquers, bitumens and slushing compounds. Paints usually are defined as mixtures of drying oils and pigments which cure by absorption of oxygen from the air. Enamels generally are pigmented mixtures of oil modified resins which cure by absorption of oxygen

from the atmosphere or which may be polymerized by heat. Lacquers are comprised of solutions of resins or a mixture of resins and plasticizers which harden or cure by evaporation of the solvent. Slushing compounds usually are made from petroleum bases with inhibiting substances added to retard corrosion.

Oils ordinarily employed in the manufacture of protective coatings are tung, linseed, dehydrated castor and soya. A limited amount of oiticica and other vegetable oils, however, is employed for special purposes in many formulations. As listed, the oils appear in the order of their rate of cure or "drying" and in the hardness of the cured films of comparable formulations. Similarly the amount of their discoloration or yellowing when employed in baking enamels approaches the same order of listing. The amount of oil used in conjunction with a given weight of resin is termed the oil length of the enamel vehicle and in the case of varnishes, is expressed in gallons of oil per 100 lbs. of hard gum. In general greater flexibility is associated with greater oil length but the shorter oil length enamels tend to cure faster.

Resins most frequently employed in industrial enamel formulation are phenolics, alkyds, rosin derivatives and melamine and urea formaldehydes. The phenolics provide good water resistance but generally poor color retention. A typical synthetic spar varnish contains about 100 lb. of phenolic resin and 30-50 gallons of drying oil. Enamels based on alkyd resins are characterized by their flexibility, color retention and good adherence to metal surfaces. The melamine and urea-formaldehydes are used to impart hardness and rapid curing properties to baked finishes.

Resins employed in lacquers include the cellulose derivatives, vinyls, acrylic esters and a large number of special materials such as chlorinated rubber, furane resins, etc. These materials have varying degrees of resistance to moisture, chemicals and weather. They also provide a wide range in physical properties. In general they must be compounded with other materials to get proper flexibility and adherence. Softening and flexibilizing components of lacquers are called plasticizers and cover a very wide range of organic substances from drying and non-drying oils to very complex synthetic organic compounds.

\* Presented at NACE Conference in St. Louis, Mo., April 5-8, 1948.  
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Pigments employed in organic finishes may be chosen for specific properties other than imparting color. Lead oxide and chromate tend to impart passivity to iron or steel surfaces in the presence of any moisture which may permeate a film of paint or enamel. Metallic pigments such as aluminum may impart improved impermeability or reflect deteriorating light rays. Still other pigments react with some component of the vehicle and give improved physical or chemical performance. Paints or enamels containing zinc dust or zinc oxide are said to have improved adherence to zinc surfaces because free fatty acids do not form soaps at the metal-film interface but are absorbed by the pigment.

The familiar black enamel on the metal parts of the telephone is an example of an organic finish which has been built to special requirements. The physical requirements are unusually severe because the instrument is subjected to abrasion, scratching, impact and to perspiration. The enamel must adhere to a zinc base die casting and to cold rolled steel or aluminum and as production rates are high it must be capable of rapid cure in conveyORIZED infra-red ovens. As it is processed in both new and old installations, the finish must be capable of curing in a variety of ovens and in a number of plants at widely separated locations. Earlier tests on alkyd enamels had established that satisfactory perspiration resistance could be obtained by adequately baking an enamel based on an alkyd resin containing 35-40 percent phthalic anhydride. Other vehicles such as phenolic varnishes, rosin maleate varnishes and air drying lacquers were considered but discarded on the basis of general suitability in favor of the alkyd type. A trial formulation indicated an enamel containing about 5 percent carbon black based on a linseed oil modified, glyceryl phthalate alkyd resin containing 35-40 percent phthalic anhydride would meet all of the requirements except that of a rapid cure.

With this paint as a basis the problem then became one of improving the baking characteristics of the enamel without affecting other properties. An obvious means for speeding the cure was by modification of the formula with a heat reactive resin such as butylated urea or melamine formaldehyde or through similar modification with a heat reactive phenolic resin. Both possibilities were tried and the phenolic resin was rejected as less desirable than either the urea or the melamine addition.

It was found that substitution of urea resin for approximately 20 percent of the alkyd resin solids provided sufficient hardness and cure. It also was found that about one-half as much (or 10 percent) of melamine resin was required to obtain the same result.

Each of these solutions to the problem of increasing the rate of cure adversely affected the ultimate adhesion of the film to the metal surfaces and introduced a new problem, namely that of regaining adhesion without sacrificing speed of cure. This ultimately was accomplished by the use of a shorter oil length alkyd (approximately 50 percent phthalic anhydride) and by holding the heat reactive resin content to a minimum.

The final formula consisted of 4 percent pigment suspended in a vehicle composed (on a solids basis) of 45 percent of a dehydrated castor alkyd containing 40 percent phthalic anhydride, 45 percent of a linseed alkyd containing 50 percent phthalic anhydride and 10 percent of a butylated urea-melamine formaldehyde resin. In this composition the general desirable characteristics were imparted by the alkyd type vehicle, the curing rate was controlled by the heat reactive resin and adhesion was retained in spite of this addition by the use of a very short oil alkyd.

Physical properties associated with the above variations in composition are given in Table I. When properly cured this finish withstands many years of outdoor exposure.

Another example of planned formulation is found in the design of a maintenance paint for shops, such as plating rooms, where chemicals are employed. In a case such as this the excellent properties of vinyl compounds can be exploited. Straight polyvinyl copolymer lacquers in general do not possess good adherence to metal, but if a vinyl resin containing a small amount of free maleic anhydride is used as the basis for formulation the adherence is improved greatly. Further modification generally is required to give stability to light and heat. Lead pigments or small amounts of urea formaldehyde or melamine resins may be used for this purpose. Materials of this type have found extensive use in many indoor applications where a high degree of chemical resistance is required.

An interesting example of "design" in the formulation of organic coatings for specific purposes may be found in the development, during and immediately after the war, of a type formulation covering a finish for use on steel and aluminum storage containers for ordnance material. Shortly after hostilities ceased, the problem of storing, and more important, the problem of preserving many millions of dollars worth of ordnance equipment was faced. The plan developed by the Frankford Arsenal called for pressurized, hermetically sealed storage in steel and aluminum containers. Since the equipment was to be stored in tropical areas as well as in the continental United States, a final finish for the containers had to be found which would withstand the conditions of

TABLE I—Physical Properties\*

	Cure	Impact Resistance R.P.M. <sup>1</sup>	Scratch Adhesion KG. <sup>2</sup>	Distensibility Percent	Abrasion Resistance Gms./Mil. <sup>3</sup>
Straight Alkyd 35-40 Percent Phthalic Anhydride.....	75 min. at 350° F.	>1900	15.0	>30	>60
Phenolic Modified.....	6 min. at 430° F.	750	>5.0	>30	.....
Urea Modified.....	6 min. at 430° F.	<470	>5.0	>30	.....
Present Formulation.....	5 min. at 450° F.	>1900	15.2	>30	66
Aged 1 Yr. Outdoors.....	5 min. at 450° F.	>1900	>20.0	12.6	.....

\* For a discussion of the tests indicated in Table I see "Selection of Protective Coatings for Metals" *Corrosion* 4, No. 3, p. 112, (1948) March.

<sup>1</sup> Impact resistance is given in revolutions per minute of the impact hammer.

<sup>2</sup> Scratch resistance is measured in terms of the kilograms of load on the scratching tool to cause removal of the coating.

<sup>3</sup> Abrasion resistance is given as the weight of selected carborundum required to remove a coating thickness of 0.001 inch.



humid tropical exposure. As there was not sufficient time for extensive exposure tests, the protective coating was devised from the collective knowledge of several consultants to the Ordnance Department.

It was known that a marine spar type of vehicle would be required and that pigmentation should be of a type suitable for use under extreme conditions of exposure. Based on past knowledge of marine and industrial paint formulation, a zinc dust—zinc oxide pigmented primer using either of two vehicle (phenolic spar varnish or a long oil alkyd) followed by aluminum pigmented paint of the same type were recommended for application on both bare or galvanized steel. The same top coat was used over a zinc chromate pigmented primer in the case of the aluminum containers.

Phenolic spar varnishes long had been used for normal purposes and for protection against the attacks of moisture. This type of vehicle therefore was recommended for use where resistance to immersion and moisture was required. The alkyd type of vehicle was recommended for use where resistance to chalking and sunlight was required.

The zinc dust-zinc oxide pigmentation was recommended on the basis of past experience where adherence to galvanized stock was required. Both types of pigment have given good results in the formulation of outside maintenance paints. Current reports indicate the finish is giving the satisfactory performance expected.

These examples illustrate the way in which the corrosion engineer now may build protective organic coatings on a scientific basis. He no longer is confronted with the handicap of secrecy that formerly shrouded the organic coatings art. Knowledge of the basic behavior of a vast array of materials which may be incorporated into organic coatings now equals or exceeds that which has been used in the engineering of metallic coatings. This knowledge will be increased and broadened as organic chemists study the deterioration of coating materials in the same fundamental way that corrosion engineers have tackled corrosion of metals.

### References

1. A.S.T.M. Designation D-609-45T.  
H. G. Arlt, *Metal Ind. N. Y.* **38**, 123-124 (1940).  
A.S.T.M. Designation D-823-45T.  
A. Brenner, *U. S. Nat. Bur. Stds., Jl. Res.* **20**, 357-368 (1938).  
E. S. Gallagher, *Amer. Mach.* **86**, 1155-1157 (1942).  
A. E. Schuh, H. C. Theuerer, *Ind. Eng. Chem., Anal. Ed.* **29**, 9-12 (1937).  
H. A. Gardner, *Phys. and Chem. Exam., P.V.L.&C.*, 9th Ed. 123 (1939).  
H. G. Arlt *A.S.T.M. Bull.* **89**, 5-9 (1937) Dec.  
A.S.T.M. Designation D-522-41.  
Nat. P.V.&L. Assn., Sci. Sect., *Circ.* **604**, 439-482 (1941).  
K. N. Kathju, *Ind. Eng. Chem., Anal. Ed.*, **16**, 144 (1944).  
R. J. Phair, *Bell. Lab. Record*, **XXIII** **8**, 284-286 (1945) Aug.  
H. G. Arlt, *Bell. Lab. Rec.*, **XV**, **4**, 108-110 (1936).  
C. C. Hipkins and R. J. Phair, *A.S.T.M. Bull.* **143**, 18-22 (1946) Dec.  
A. E. Schuh, E. W. Kern, *Ind. Eng. Chem., Anal. Ed.*, **3**, 72-76 (1931). A.S.T.M. Designation D-658-44.



### TECHNICAL PAPERS PROCEDURE

All papers submitted for publication in *CORROSION* are reviewed by the Editorial Review Committee, or specialists selected by that committee to review the papers. Suggestions of reviewers as to desirable additions or revisions are submitted to the author, who is given the opportunity to make the suggested changes. The paper in final form is accepted or rejected according to the judgment of the committee and the Editor of *CORROSION*. When the author can substantiate his viewpoint and prefers not to follow the suggestions of the reviewer and the overall paper merits publication, the author's wishes are followed.

# A Case of Corrosion Involving Cinders★

By C. H. THOMPSON

IN MOST CITIES underground telephone systems consist of bare lead cables that start from a central office and are routed in various directions therefrom through buried vitrified clay or creosoted wood conduits. Manholes are constructed at intervals along the conduit routes, primarily as cable splicing points. Corrosion surveys made periodically along these routes, include the measurements of potential between cable and earth at selected manholes. Where such potentials are governed by the effects of stray currents from ground return DC railways, these measurements usually provide a fair indication of the corrosion condition of the cables, not only in the manholes but also in duct sections adjacent to manholes.

Experience has shown, however, that sometimes exceptions exist when localized corrosion, not revealed by the tests at the manholes, occurs in the duct sections. While such conditions usually can be detected by a duct survey, described below, the expense of conducting such a survey limits its use in stray current areas to locations where extraordinary conditions are suspected. Thus, it sometimes happens that a cable failure is first indication of the existence of a localized corrosion condition within a manhole section.

A duct survey<sup>1</sup> is made by inserting a test electrode, or duct slug, of the same material as the cable sheathing, in a spare duct adjacent to the cables. This slug is moved through the duct either by pushing with duct rods or by pulling from the next manhole by means of a rope previously provided. Thus measurements are obtained at regular intervals of a few feet within the section under test. Measurements taken at each position of the slug consist of cable to slug potential, slug leakage resistance and slug leakage current. Standards have been established whereby the existence of unsatisfactory conditions is indicated by these measurements. Duct surveys can be employed in lieu of or in addition to the manhole measurements, but as indicated above are not considered justified economically on a general scale because of the relative rarity of local corrosion conditions, particularly in a stray current area.

## Cables Damaged by Galvanic Cell

It is the purpose here to describe a localized corrosion condition of this nature where serious damage

to the telephone cables was experienced as a result of galvanic cell generated locally and external to the cables in a bed of cinders. This case occurred in Staten Island, also known as Richmond, one of the boroughs or counties of New York City. Although mostly suburban in character, Staten Island contains many industrial establishments along the water fronts facing Manhattan and New Jersey. It is considered a stray current area, as the potentials of all underground structures reflect the influence of a local ground return DC railroad. Cables involved in this case are routed along a main thoroughfare known as Richmond Terrace which skirts the northern shore of the island as shown in Figure 1. Included among them are toll cables connecting Staten Island with New Jersey and Manhattan.

Routine surveys at manholes had for many years indicated that satisfactory potentials existed along this route as a result of stray current drainage to several railroad substations in the vicinity. Recently, however, the failure of one of the toll cables in this route occurred. Measurements disclosed the point of failure as being three sections out from the central office on Richmond Terrace in a 524-foot section which at approximately its center crosses a culvert over a body of water known as Bodine Creek. The failure was located in the center of the culvert, a reinforced concrete structure, some 40 feet in length. The construction on the culvert is shown in Figure 2.

A small excavation was made at the trouble location and the exposed cable was found to be perforated and badly pitted from corrosion. Examination of the other cables at the excavation disclosed them

**ABOUT THE AUTHOR—C. H. Thompson** has been employed by the New York Telephone Company since 1923 during which time he has been engaged in cable maintenance, particularly as it concerns corrosion prevention. During the past twelve years as electrolysis supervisor he has been responsible for prevention and mitigation of corrosion of all underground plants in the Long Island area in which Brooklyn, Queens and Richmond Boroughs of New York are a part. His duties include maintaining cordial working relations with other companies and municipal departments having underground systems.



★A paper presented at the NACE Conference in St. Louis, Mo., April 5-8, 1948.

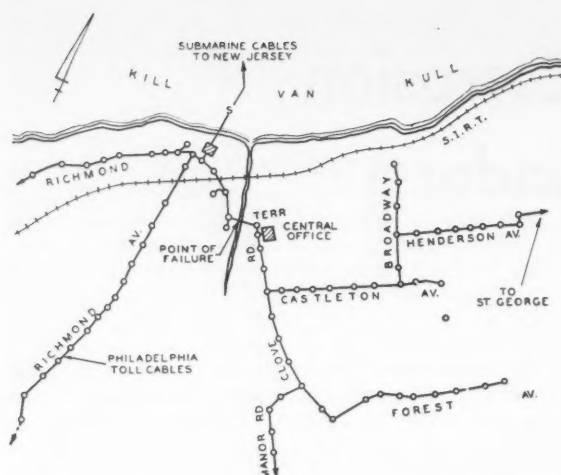


Figure 1—Cable routes near Port Richmond Central Office.

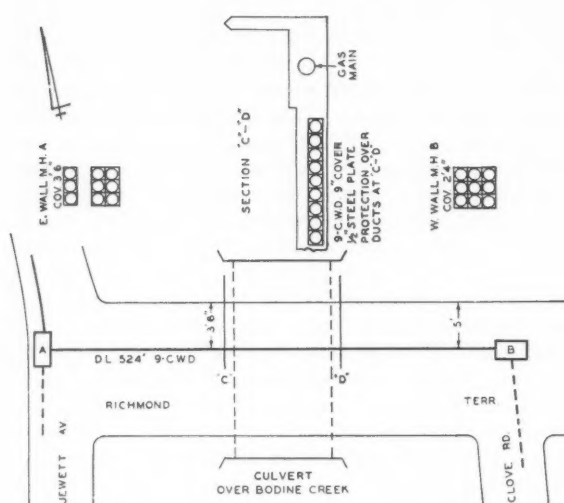


Figure 2—Duct arrangement on Richmond Terrace between Jewett Ave. and Clove Road.

to be similarly pitted. Suspicion as to the cause of the corrosion was aroused by the fact the fill around the ducts consisted entirely of bituminous cinders containing unburned carbon. Measurements at the excavation disclosed the existence of high positive cable-to-earth potentials indicative of a severe anodic condition affecting the cables. A duct measurement showed a similar result and revealed that these harmful potentials were confined to the portion of the duct section on the culvert. The defective cable was temporarily repaired to maintain service and when subsequently removed was found to be badly pitted for that portion of its length over the culvert while the portions on either side off the culvert were in perfect condition.

The excavation made at the time of the temporary repairs also revealed the existence of an 8-inch gas main parallel and adjacent to the conduits, half imbedded in the concrete of the culvert; the other half

covered with the cinders. The location of the main with respect to the cables is shown in Figure 3.

### Water Drained to Culvert Section

The telephone conduits on the structure are of creosoted wood and lie in a splayed horizontal formation which was necessitated by the shallow cover available on the culvert. The portion of the conduit on the culvert is at a lower level than the conduit on either side. The adjacent manholes and the conduit fill up with ground water which flows toward the culvert. As the water cannot drain from the culvert it is trapped in the conduit.

Tests indicated the positive potentials previously mentioned were caused by a galvanic couple on the culvert, as shown in Figure 4. This galvanic couple was set up by the iron gas main and the carbonaceous matter in the cinders. The pipe on the approaches to the culvert was anodic in respect to the carbon which was, of course, in contact with the main on the culvert. The current of this couple was directed through the earth along lines parallel to the gas main and telephone cables. Part of these earth currents were picked up by the cable sheaths on the approaches and left the sheaths on the culvert to get to the cinders. The trapped water in and around the conduit acted as a low resistance electrolyte, thus aggravating the corrosive action on the cable sheaths. Positive cable-to-duct potentials of .2 volt were observed as were potentials as high as plus .58 volt be-

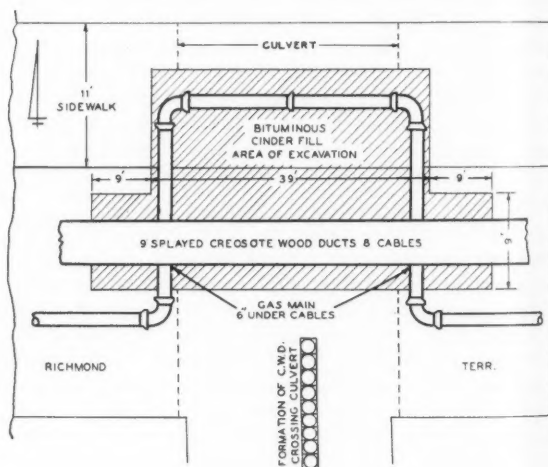


Figure 3—Layout of gas main and telephone ducts at Bodine Creek culvert.

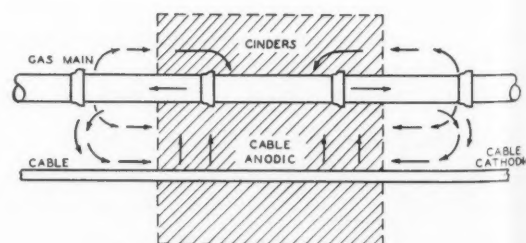


Figure 4—Effect of iron-carbon couple.



tween the cables and a lead-chloride half-cell placed at various points on the surface of the earth above the gas main and in the excavation.

A number of possible solutions to this problem were considered among which were the following:

- a) Forced drainage of five amperes from a rectifier located in the Central Office.

It was determined the harmful potentials on the culvert could be eliminated by this amount of drainage to an anode located in a spare duct parallel to the affected cables. This solution was abandoned as the high current discharge would necessitate frequent replacement of the anode and cause excessive accumulation of corrosion product in the duct line.

- b) Replacement of all cables in the affected section between the manholes on both sides of the culvert with others having a corrosion protected covering.

This solution was rejected on the grounds of high cost and the probability that difficulty would be experienced in pulling the corrosion protected cable through such a long section of wood conduit, a distance of over five hundred feet.

- c) Excavating and exposing the cables on the culvert and covering them with pipe line felt.

This measure had the advantage it would provide an opportunity to repair damage to the sheaths. However, in covering the cables with felt, future removals because of obsolescence, etc., would be difficult and costly. This would interfere seriously with future provisions for growth as the duct line in question is the major route for cables from the Port Richmond Central Office.

- d) Excavating and exposing the gas main and covering it with felt or some similar material.

This idea was discarded as being impracticable because of the difficulty of exposing the main because it was partly imbedded in concrete and was situated under a footwalk which otherwise would not have to be disturbed.

- e) Isolation of the cable sheaths over the culvert by constructing a new manhole at each end of the culvert and installing insulating joints in all cables at each end, thereby preventing the flow of current.

This solution was rejected because the manholes would be filled with water continuously and some misgiving existed as to whether the insulating joints would remain water-tight if continuously submerged over a long period of time.

- f) It finally was decided to expose the cables and gas main for the full length of the culvert, repair all damage to the cables, remove all cinders from the vicinity of the gas main and conduit, and replace the cinders with clean sand. An advantage of this plan was it provided for cable repairs over the entire damaged portion of the section although some doubt did exist as to whether a satisfactory job could be accomplished in removing the cinders.

The opening was made as shown in Figure 5, and the cables were found to be seriously pitted for the full length of the culvert and it was evident that



Figure 5—Excavated cables on Bodine Creek culvert.

additional failures would have occurred within a short time. The cables were repaired carefully by wiping solder over the areas where small pits were found and by soldering lead sleeves over the badly pitted areas. When the ducts had been restored and all loose cinders had been removed the excavation was partially filled with clean sand. Tests were made then to determine effectiveness of the measures taken.

The harmful positive potentials had by no means disappeared. The measurements disclosed conditions similar to those that existed before the work was undertaken.

The gas main was exposed again and closely examined. What originally had appeared to be a rough coating of rust was found to consist actually of a hard two-inch crust of carbon-bearing cinders adhering strongly to the main. With the cooperation of the gas company it was necessary to chip this crust from the main. After the main had thus been cleaned and with the sand back-fill in place, tests were again made. It was found positive potentials had disappeared entirely indicating the iron-carbon cell had been eliminated. Cables in the culvert assumed the same satisfactory negative potential as in other portions of the section, as shown in graph on Figure 6.

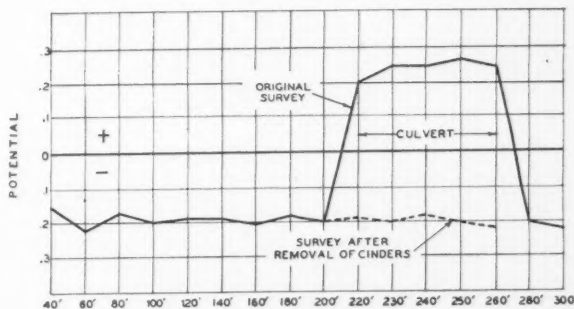


Figure 6—Duct survey. Section on Richmond Terrace between Clove Road and Jewett Ave. (Horizontal distances are those from manhole at Richmond Terrace and Jewett Ave.)

### References

1. L. J. Gorman, *Electrolysis Surveys on Underground Cables*, Corrosion 1, 163-177 (1945) Dec.

### DISCUSSION

By L. J. GORMAN\*

I happen to be personally acquainted with the case discussed by Mr. Thompson. This is by no means an isolated case. Similar cases of corrosion occur quite frequently in this Metropolitan Area. We have a great deal of filled ground, in which the fill consists of cinders and various other kinds of refuse. A common practice is to bury expensive structures in the form of lead-covered power and telephone cables, gas pipes, water pipes, etc., in this type of soil. When these structures start to corrode in a very few years, the people who are responsible for their installation, very innocently, wonder why.

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Mr. Thompson has picked out an individual case which is more or less typical of many cases and has discussed its essential features with a view to impressing them on the minds of those responsible. I might say that our most serious corrosion problems here in the Metropolitan Area result from the indiscriminate use of cinders and refuse in filled ground.

The conditions can be partially remedied by excavating the cinders as much as practicable, and backfilling with clean earth around the pipe or cable ducts. A more effective remedial measure is to use coated pipe or cable sheath with a protective jacket.

Another practice in our city is that of spreading salt on the streets to melt snow. In this way, salt water gets into our cable manholes, cable ducts and around the pipes; thus setting up a serious corrosion condition which becomes more serious with time. The use of salt for snow melting is also a serious factor in corroding the under bodies of motor vehicles.

## TECHNICAL PAPERS UNDER REVIEW OR BEING CONSIDERED FOR EARLY PUBLICATION IN CORROSION MAGAZINE

**Insulated Joints**—By Dr. W. Beck, Department of Metallurgical Engineering, Lehigh University, Bethlehem, Pa.

**Corrosion Problems in a Modern Fluid Catalytic Cracking and Fractionation Unit**—By Nathan Schofer, Cities Service Refining Corp., Lake Charles, La.

**The Behavior of Bituminous Pipe Coatings Under Bending Vibration Stress**—By Dr. W. Beck, Lehigh University, Bethlehem, Pa.

**Corrosion Problems in the Manufacturing of Sulfuric Acid**—By T. L. Hart, National Zinc Co., Bartlesville, Okla.

**Steam Reboiler Corrosion**—By W. S. Janssen, Pan American Refining Corp., Texas City, Texas.

**Value of Backfill With Carbon and Graphite Anodes**—By J. P. Oliver, National Carbon Co., Cleveland, Ohio.

**Preliminary Evaluation of Resinous Coatings**—By W. R. Smith, Nukem Products Corp., Buffalo, N. Y.

**Microscope As An Aid in Corrosion Problems**—By H. M. Wilten, The Texas Company, Port Arthur, Texas.

**Special Anodes for Cathodic Protection of Water Tanks**—By A. L. Kimmel, Assistant Research Engineer, Engineering and Industrial Experiment Station, University of Florida, Gainesville, Fla.

**Some Aspects of Buried Stainless Steel Pipe at the Hanford Works**—By R. F. Plott, Associate Physicist, Argonne National Laboratory, Chicago, Ill.

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**Corrosion in Sulphur Production; The Use of an Alloy Protective Coating**—By Norman Hackerman, Department of Chemistry, University of Texas, Austin, Texas.

**Corrosion Resistance of Sprayed Metal Coatings**—By Walter B. Meyer, John Nooter Boiler Works, St. Louis, Mo.

**How the Corrosion of Metals Is Promoted and Accelerated by Micro-Organisms**—By C. O. Evans, Phelps-Dodge Copper Corp., New York, N. Y.

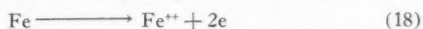
# Effect of Various Aqueous Solutions Upon the Reactions at Pure Iron Anodes and Cathodes — Part II

By W. W. KITTELBERGER and A. C. ELM

## II—Anodic Reactions

This phase of the investigation dealt with the effect of various solution constituents upon the current-potential relationships obtained with a pure iron anode.

Figure 4 shows two typical current-potential curves for a Puron anode in oxygen-free N/10  $K_2SO_4$  solutions. In the chromate-free solution, the electrode became anodic at a potential of about  $-0.7$  volt, and began to dissolve by a reaction which may, for the sake of simplicity, be written as



As the potential was made more positive, the anodic current and the accompanying dissolution of the metal increased rapidly. This is shown by branch DE of the curve in Figure 4.

Curve DFG illustrates an anodic current-potential relationship which may be obtained in several ways, although always with an anode which cannot be oxidized (except superficially) at potentials more negative than that at which oxygen is evolved by the electrolysis of water. In Figure 4, FG shows the relationship between the anode potential and the cell current during the evolution of oxygen at the electrode surface. The zero current portion of the curve, DF, may result from the use of a noble metal electrode such as platinum, or from the use of a base metal and a corrosion inhibitive solution in which its behavior is similar to that of a noble metal. Thus a curve identical with DFG could be obtained with an iron anode in oxygen-free N/10  $K_2SO_4$  solution containing 4.8528 grams of  $K_2CrO_4$  per liter at pH = 8.0.

In the anodic or positive current region, curves DE and DFG represent, for an iron electrode, the limiting cases of free or uninhibited

corrosion, and of complete inhibition of corrosion, respectively. Thus anodic curves falling between these limits will be obtained when the anodic reaction is neither completely inhibited nor entirely unhindered, that is, when some form of "anodic control" is operative.

### 1. The Effect of Variation in Hydrogen Ion Concentration Upon the Behavior of a Pure Iron Anode

The curves in Figure 5 show the relationship between cell current and the potential of a Puron anode in oxygen-free N/10  $K_2SO_4$  solutions adjusted to different pH values. In the pH range from 4 to 10 the experimental data indicate that variations in hydrogen ion concentration had no significant effect upon either the potential at which the electrode



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ADOLF C. ELM

Joined the Research Division of the New Jersey Zinc Company (of Pa.) in 1929. A native of Germany, he graduated in chemistry from the University of Marburg, Hessen, came to the United States in 1924 and began working in the protective coatings industry, first in technical service and for the last 20 years in research. His publications since joining New Jersey Zinc Company have dealt with drying oils, pigments and paints, the theory of film formation and the mechanism of action of protective coatings.



became anodic, or upon the general character of the anodic (positive) current curves. At a pH of 2.0 the electrode did not become anodic until a more positive (by about 0.1 volt) potential had been reached, although thereafter, this curve was identical with the others in shape. It already has been pointed out in the case of the pH 2 test, hydrogen ions were discharged at a relatively rapid rate at the electrode surface before the anodic portion of the curve was reached. This hydrogen ion reduction would result in a marked change in the pH of the unbuffered solution in direct contact with the electrode, which probably would account for the more positive potential at which the electrode became anodic. This effect also may be observed in a number of the other tests discussed in this report.

The curves in Figure 6 were obtained with oxygen-free N/10 KCl solutions varying in pH from 2 to 10. They are identical with the curves in Figure 5 for

N/10  $K_2SO_4$  solutions, indicating that  $SO_4^{2-}$  and  $Cl^-$  do not differ in their direct effect upon the anodic reaction. However, a secondary effect in which they do differ will be discussed later in this article.

Figure 7 was included to show that under the conditions of these experiments the primary anodic reaction is not directly influenced by the presence or absence of dissolved oxygen in the electrolyte. This is based upon the observation that anodic curves obtained with air saturated N/10 KCl solutions adjusted to various pH levels (Figure 7) are identical with the anodic curves for the same solutions freed of dissolved oxygen (Figure 6).

Most marked effect of variations in the hydrogen ion concentration upon the anodic reaction was observed when the electrolyte also contained some chromate ions. This is illustrated clearly by the current-potential curves presented in Figures 5, 24 and 25. These tests were made with a 2-mm<sup>2</sup> Puron elec-

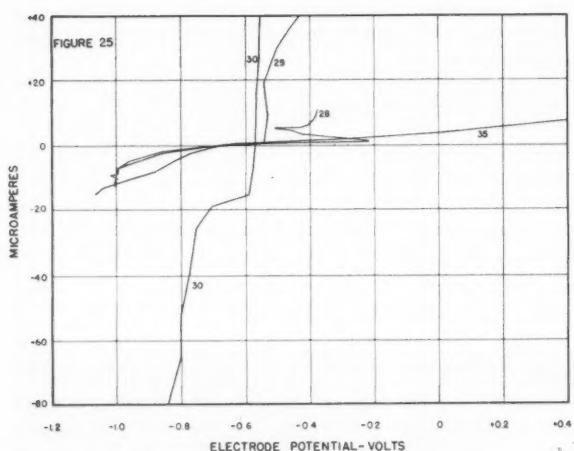


Figure 25—Effect of variations in hydrogen ion concentration in oxygen-free N/10  $K_2SO_4$  in the presence of chromate ion. 4.8528 g.  $K_2CrO_4$  per liter—2 mm<sup>2</sup> Puron electrode. No. 30—pH = 2.0; No. 29—pH = 4.0; No. 28—pH = 6.0; No. 35—pH = 8.0.

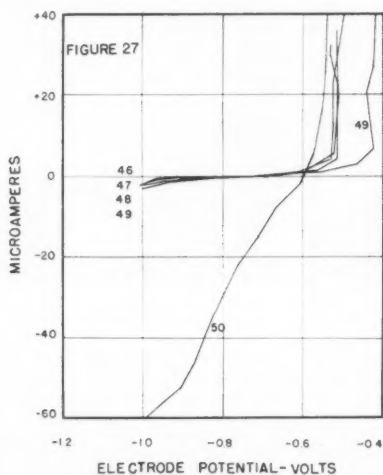


Figure 27—Effect of variations in the hydrogen ion concentration of oxygen-free N/10 KCl containing 0.4853 g.  $K_2CrO_4$  per liter. 2 mm<sup>2</sup> Puron electrode. No. 50—pH = 2.0; No. 49—pH = 4.0; No. 48—pH = 6.0; No. 47—pH = 8.0; No. 46—pH = 10.0.

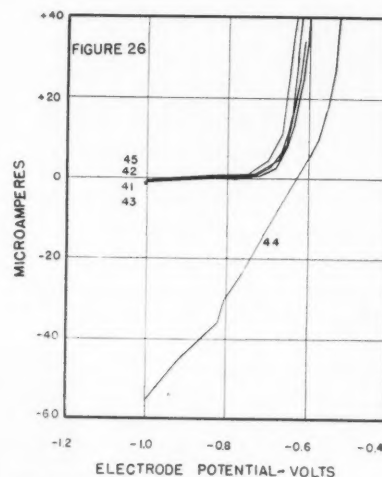


Figure 26—Effect of variations in the hydrogen ion concentration of oxygen-free, chromate-free N/10 KCl. 2 mm<sup>2</sup> Puron electrode. No. 44—pH = 2.0; No. 43—pH = 4.0; No. 41—pH = 6.0; No. 42—pH = 8.0; No. 45—pH = 10.0.

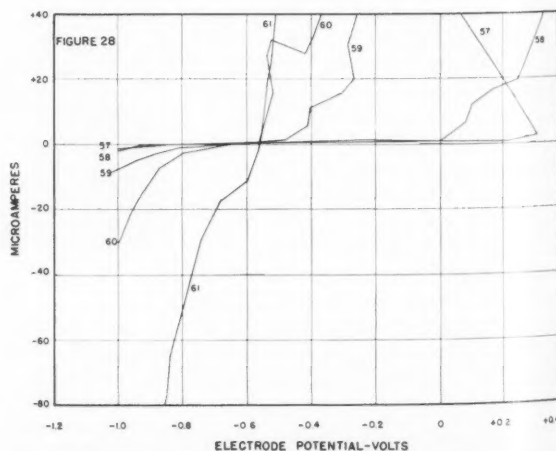


Figure 28—Effect of variations in the hydrogen ion concentration of oxygen-free N/10 KCl solution containing 33.9696 grams  $K_2CrO_4$  per liter. 2 mm<sup>2</sup> Puron electrode. No. 61—pH = 2.0; No. 60—pH = 4.0; No. 59—pH = 6.0; No. 58—pH = 8.0; No. 57—pH = 10.0.

trode in oxygen-free N/10  $K_2SO_4$  solutions at various hydrogen ion concentrations and containing O, 0.4853, and 4.8528 grams of  $K_2CrO_4$  per liter, respectively.

By comparing Figures 5 and 24, the potential at which the electrode became anodic is seen to be somewhat more positive (by around 0.1 volt) in the presence of 0.4853 gram  $K_2CrO_4$  per liter, than in the absence of chromate. The most important difference was noted in the pH 8 solutions. At this hydrogen ion concentration in the presence of chromate, the electrode became anodic at a potential of  $-0.75$  volt, but the anodic current increased to only 3 microamperes while the potential changed to  $-0.17$  volt. At this latter point, the current suddenly began to increase spontaneously, (that is, without further change in the applied emf) and the potential became more negative. The result of this spontaneous change was to return the current-potential curve to a position which might be called its normal one for the unhindered primary anode reaction  $Fe \rightarrow Fe^{++} + 2e$ . This behavior is believed to be a result of formation of a protective layer of oxide or corrosion product on the iron surface. At pH 8.0 this layer was formed and greatly retarded corrosion in the presence of 0.4853 gram of  $K_2CrO_4$  per liter, but did not form in the absence of chromate. That the layer was not completely protective, or that it formed and was maintained by a small anodic current, is indicated by the measurable current that was observed between  $-0.75$  and  $-0.17$  volt. The spontaneous return of the potential to a value corresponding to normal or uninhibited corrosion represents the complete destruction of the protective layer.

It should be noted that a protective layer was formed only in the pH 8 solution but it did not inhibit corrosion completely and broke down spontaneously. At hydrogen ion concentrations higher than

that corresponding to pH 8 there was no evidence of the inhibition of corrosion.

The effect of a tenfold higher concentration (4.8525 gram per liter) of chromate is illustrated by the four curves in Figure 25. In this case and presumably because of the higher concentration of chromate ions, there is evidence of protective film formation at hydrogen ion concentrations as high as that corresponding to pH 4.0 (0.0001 M).

The potential at which destruction of the protective layer begins apparently is a measure of its stability. The effect of pH variations is clearly shown in Figure 25 by the potentials at which destruction of the anodic films started. These values, which were  $-0.54$ ,  $-0.22$  and  $+0.40$  volt for the pH 4, 6, and 8 solutions, respectively, indicate stability of the protective layer increases with decreasing hydrogen ion concentration.

Curve No. 28 in Figure 25 indicates that in some cases the protective anodic film may form again after it once is destroyed. Periodic fluctuations in the current and potential, of which curve No. 28 gives but a hint, have been observed with many metals by E. S. Hedges<sup>5</sup> who ascribes them to the alternate formation and destruction of protective anodic films.

Figures 26, 27, and 28 were obtained with a Puron electrode in oxygen-free solutions of N/10 KCl at various pH levels, and containing O, 0.4853, and 33.9696 grams of  $K_2CrO_4$  per liter. They thus provide data to show the effect of variations in hydrogen ion concentration in the presence of  $K_2CrO_4$  and an anion, namely, chloride, which is generally supposed to be more corrosive than sulfate. In the absence of chromate ion (Figure 26), the curves obtained with KCl solutions are identical with those obtained in  $K_2SO_4$  solutions of the same normality (Figure 5), as already has been pointed out. Anodic current curves in

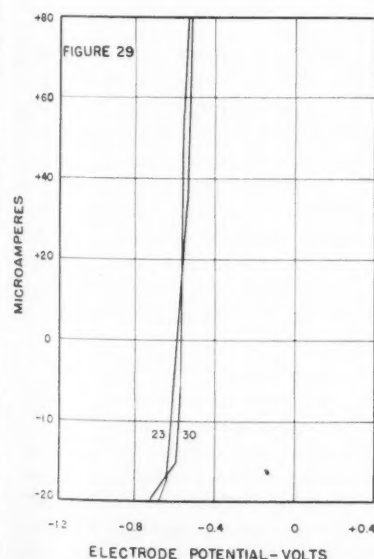


Figure 29—Effect of variations in dissolved oxygen concentration of N/10  $K_2SO_4$  solutions containing 4.8528 grams  $K_2CrO_4$  per liter at pH = 2.0. 2 mm<sup>2</sup> Puron electrode. No. 30—oxygen-free; No. 23—air-saturated.

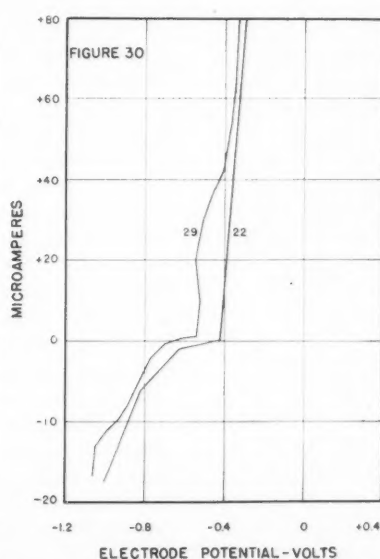


Figure 30—Effect of variations in dissolved oxygen concentration of N/10  $K_2SO_4$  solutions containing 4.8528 grams  $K_2CrO_4$  per liter at pH = 4.0. 2 mm<sup>2</sup> Puron electrode. No. 29—oxygen-free; No. 22—air-saturated.

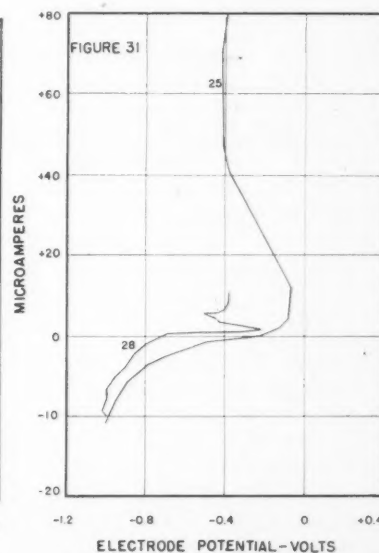


Figure 31—Effect of variations in dissolved oxygen concentration of N/10  $K_2SO_4$  solutions containing 4.8528 grams  $K_2CrO_4$  per liter at pH = 6.0. 2 mm<sup>2</sup> Puron electrode. No. 28—oxygen-free; No. 25—air-saturated.

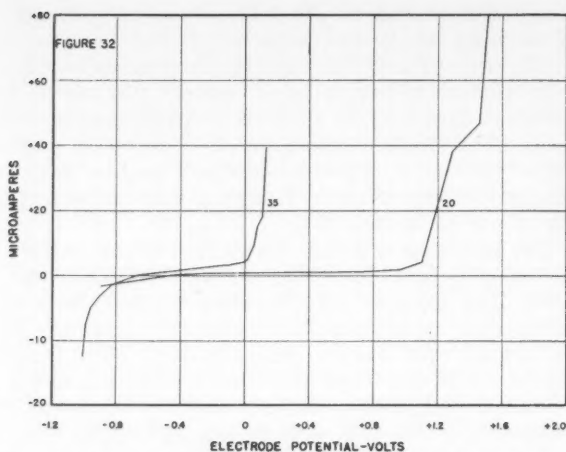


Figure 32—Effect of variations in oxygen concentration of N/10  $K_2SO_4$  solutions containing 4.8528 grams  $K_2CrO_4$  per liter at  $pH = 8.0$ . 2 mm<sup>2</sup>. = Puron electrode. No. 35—oxygen-free; No. 20—air-saturated.

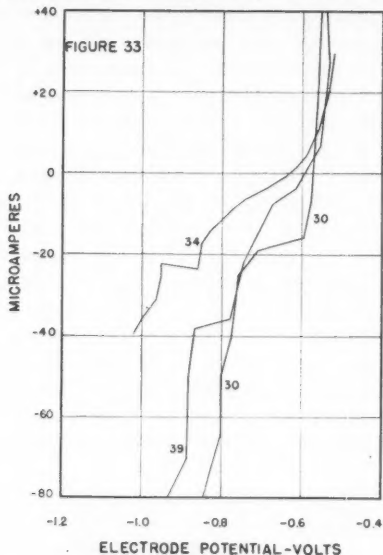


Figure 33—Effect of variations in chromate ion concentration of oxygen-free N/10  $K_2SO_4$  solution at  $pH = 2.0$ . 2 mm<sup>2</sup>. Puron electrode. G.  $K_2CrO_4$  per liter: No. 34—0; No. 39—0.4853; No. 30—4.8528.

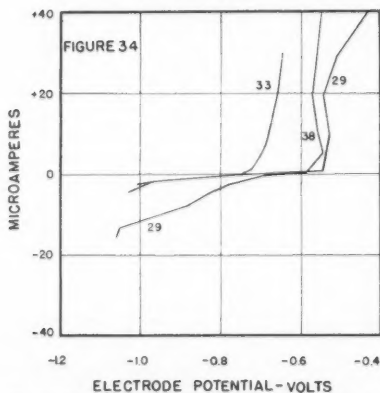


Figure 34—Effect of variations in chromate ion concentration of oxygen-free N/10  $K_2SO_4$  solution at  $pH = 4.0$ . 2 mm<sup>2</sup>. = Puron electrode. G.  $K_2CrO_4$  per liter: No. 33—0; No. 38—0.4853; No. 29—4.8528.

Figure 27 were obtained with N/10 KCl containing 0.4853 gram per liter of  $K_2CrO_4$  and they show that the effect of variations in hydrogen ion concentration was negligible. It may be noted by comparing Figures 26 and 27, that the potential at which the electrode became anodic was about 0.1 volt more positive in the presence of 0.4853 gram  $K_2CrO_4$  per liter than in its absence. This also was evident with the  $K_2SO_4$  solutions. When the concentration of  $K_2CrO_4$  was increased to 33.9696 grams per liter, the effect of pH variations became very marked, just as it did with  $K_2SO_4$  solutions but at the much lower  $K_2CrO_4$  concentration of 4.8528 grams per liter. The curves for this high concentration of chromate (Figure 28) show that protective anodic films were formed at hydrogen ion concentrations corresponding to pH values of 6, 8, and 10 and that in KCl solutions also, the stability of these films increased with decreasing hydrogen ion concentration.

## 2. The Effect of Variations in the Dissolved Oxygen Concentration Upon the Behavior of a Pure Iron Anode

The effect of variations in the amount of oxygen dissolved in the electrolyte upon the primary anodic reaction with a pure iron electrode is indicated by the data presented in Figures 12 and 13 to 17.

The curves in Figure 12 were obtained with a Puron electrode in oxygen-free, air-saturated, and oxygen-saturated N/10 KCl solutions at  $pH = 6.0$ . These solutions contained approximately 0, 0.00025, and 0.00125 moles of oxygen per liter, respectively. Except for the fact the potential at which the electrode became anodic moved about 0.05 volt in the positive direction with each increase in oxygen concentration, anodic current curves were identical for these three solutions. This indicates that under these experimental conditions the primary anodic reaction was essentially unaffected by variations in the dissolved oxygen concentration.

The five pairs of curves in Figures 13 to 17 support this conclusion. They were obtained with oxygen-free and air-saturated N/10 KCl solutions at various hydrogen ion concentrations. In this case also it may be noted that the potential at which the current passed through zero was more positive in the presence than in the absence of dissolved oxygen. Otherwise the effect of this variation in oxygen concentration (0 to 0.00025 moles per liter) upon the anodic current curves appears to have been negligible (within experimental error) at hydrogen ion concentrations between pH 2 and pH 10.

Figures 29 to 32, inclusive, contain four pairs of curves which were obtained with oxygen-free and air-saturated N/10  $K_2SO_4$  solutions containing 4.8528 grams of  $K_2CrO_4$  per liter and adjusted to four different hydrogen ion concentrations. At pH 2 (Figure 29), the curves for the oxygen-free and the air-saturated solutions may be considered identical. At pH 4 (Figure 39), the electrode became anodic at a 0.2-volt more positive potential in the air saturated than in the oxygen-free solution. Otherwise, the anodic current curves for these two solutions can be considered identical, especially at the higher current levels.



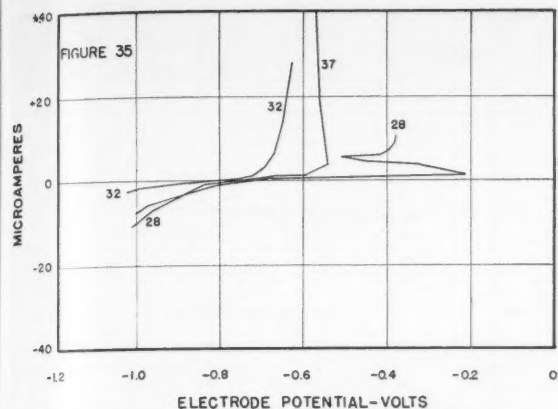


Figure 35—Effect of variations in chromate ion concentration of oxygen-free N/10  $K_2SO_4$  solution at pH = 6.0, 2 mm<sup>2</sup> Puron electrode. G.  $K_2CrO_4$ , per liter; No. 32—0; No. 37—0.4853; No. 28—4.8528.

At the still lower hydrogen ion concentration corresponding to a pH of 6.0 the curves in Figure 31 indicate the presence of dissolved oxygen began to have a more significant effect upon the anode behavior. In the absence of oxygen the current passed through zero at a potential of -0.70 volt, and by continuing at a low level to a potential of -0.21 volt, showed the presence of a protective anodic film. After being destroyed at -0.21 volt, the curve indicates what probably was a tendency for this protective layer to reform, but at a potential of -0.38 volt, the current began to rise rapidly.

In the air-saturated solution the anodic current curve is more difficult to interpret. It began at -0.24 volt and the anodic current increased more and more rapidly as the potential moved in the positive direction. When it reached a value of -0.07 volt the potential spontaneously shifted back to -0.38 volt and the current increased from 12 to 42 microamperes. This spontaneous change in potential in the negative direction is assumed to result from or indicate the destruction of a more or less protective anodic film. In the light of present knowledge it is difficult to decide whether the more stable film was produced in the oxygen-free or in the air-saturated solution. It is interesting to note that at the higher anodic currents the two curves in Figure 31 probably would be identical.

In N/10  $K_2SO_4$  solutions containing 4.8528 grams of  $K_2CrO_4$  per liter, an increase in the oxygen concentration from practically zero to 0.00025 mole per liter had a profound effect at pH 8, upon the anodic current-potential curves for a pure iron electrode, (see Figure 32). In the oxygen-free solution the anodic current curve starts at -0.68 volt but the current did not begin to rise rapidly until the potential had reached a value of 0 volt. With the same solution saturated with air, the current passed through zero at about -0.43 volt and attained a value of 2 microamperes only at a potential of almost +1.0 volt. At potentials more positive than +1.0 volt the current increased rapidly due to the electrolysis of water with the evolution of oxygen at the electrode surface.

In the presence of dissolved oxygen the current-

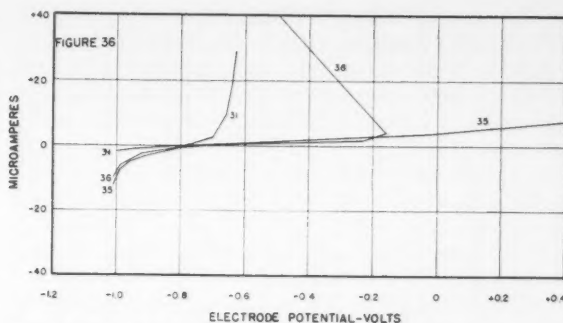


Figure 36—Effect of variations in chromate ion concentration of oxygen-free N/10  $K_2SO_4$  solution at pH = 8.0, 2 mm<sup>2</sup> Puron electrode. G.  $K_2CrO_4$ , per liter; No. 31—0; No. 36—0.4853; No. 35—4.8528.

potential curve (No. 20) indicates practically complete inhibition of corrosion throughout the entire range of potentials studied. The character of the current-potential curve obtained in the oxygen-free solution indicates the anode reaction was inhibited to a considerable extent, although much less effectively than when dissolved oxygen was present. The rapid increase in anodic current at about +0.10 volt must mean the potential still was being affected by the presence of some kind of anodic film, which, however, was not affording complete protection. It is possible that at some still higher current this anode layer would be destroyed completely and the potential would return to a normal value for unhindered corrosion (around -0.7 volt). Or, at higher current densities the anodic film might become more effective as will be discussed later.

It is concluded that the primary anodic reaction with an iron electrode is unaffected by dissolved oxygen. However, through secondary reactions, probably generally with the anodic reaction products, oxygen can, under certain conditions, greatly affect the anode behavior. For example, it appears to require a higher concentration of chromate ions to attain a given degree of inhibition in an oxygen-free solution than in one that is saturated with air. Thus oxygen assists in the formation of protective anodic films, and probably improves their stability. In other words, oxygen could be considered to be an anodic polarizer, although its effect may be so small as to escape notice unless other similar materials (chromates for example) also are present.

### 3. The Effect of Variations in Chromate Ion Concentration Upon the Behavior of a Pure Iron Anode

Current-potential measurements were made with a Puron electrode in a number of different solutions to determine the effect of variations in the chromate ion concentration upon the anodic reaction.

The curves in Figures 33 to 36, inclusive, show changes in the anodic current that occurred when the potential of a pure iron anode was varied. These results were obtained with oxygen-free N/10  $K_2SO_4$  solutions containing three different concentrations of  $K_2CrO_4$  at four hydrogen ion concentrations. Figure 33 shows that at pH 2.0, increasing the  $K_2CrO_4$  concentration of the N/10  $K_2SO_4$  solution had no signifi-

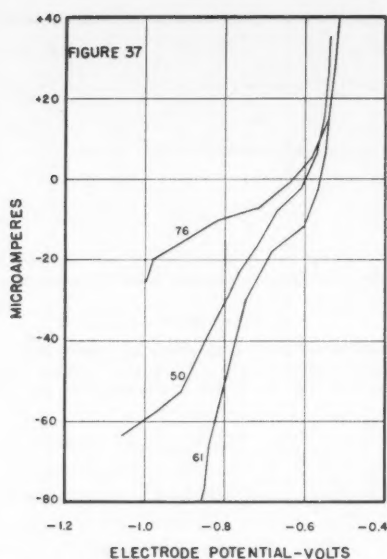


Figure 37—Effect of variations in chromate ion concentration of oxygen-free N/10 KCl solution at pH=2.0. 2 mm<sup>2</sup>—Puro electrode. G. K<sub>2</sub>CrO<sub>4</sub> per liter: No. 76—0; No. 50—0.4853; No. 61—33.9696.

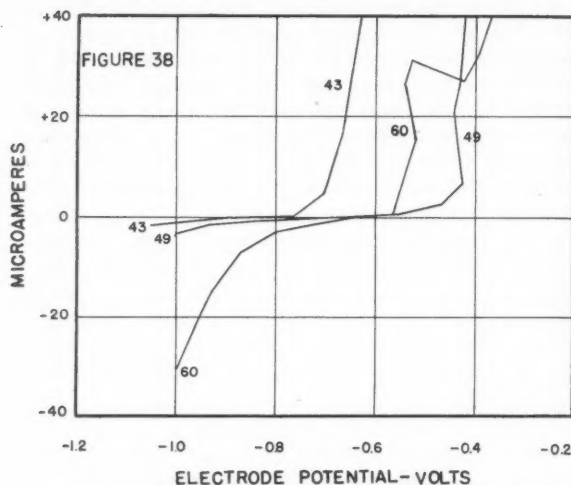


Figure 38—Effect of variations in chromate ion concentration of oxygen-free N/10 KCl solution at pH=4.0. 2 mm<sup>2</sup>—Puro electrode. G. K<sub>2</sub>CrO<sub>4</sub> per liter: No. 43—0; No. 49—0.4853; No. 60—33.9696.

cant effect upon the anodic current, although the potential at which the electrode became anodic was shifted about 0.03 volt in the positive direction for each increment. At a hydrogen ion concentration corresponding to pH=4.0, the anodic current curves for K<sub>2</sub>CrO<sub>4</sub> concentrations of 0, 0.4853, and 4.8528 grams per liter show more significant differences (see Figure 34). In this instance effect of the chromate is shown by a definite shift in the positive direction, of the potential at which the electrode became anodic. This displacement amounted to about 0.07 volt for 0.4853 gram per liter of K<sub>2</sub>CrO<sub>4</sub> and about 0.11 volt for the solution containing 4.8528 grams per liter of K<sub>2</sub>CrO<sub>4</sub>. At a pH of 6.0, the effect of the K<sub>2</sub>CrO<sub>4</sub> was definitely more marked than at higher hydrogen ion concentrations. This is clearly shown in Figure 35 by the displacement of the anodic curves to more posi-

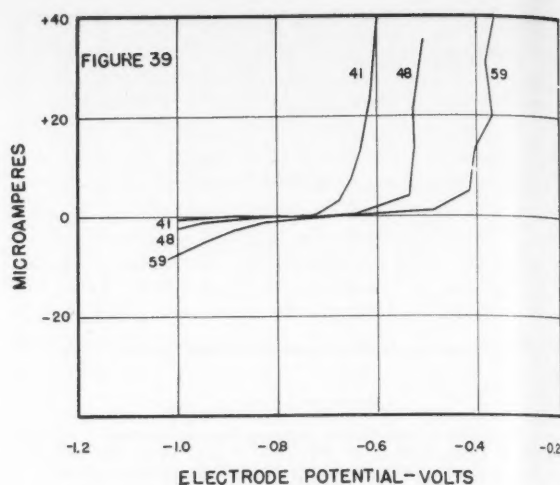


Figure 39—Effect of variations in chromate ion concentration of oxygen-free N/10 KCl solution at pH=6.0. 2 mm<sup>2</sup>—Puro electrode. G. K<sub>2</sub>CrO<sub>4</sub> per liter: No. 41—0; No. 48—0.4853; No. 59—33.9696.

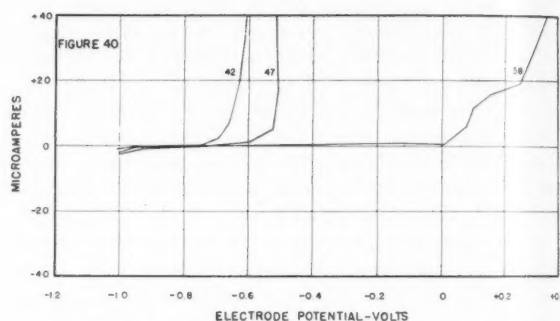


Figure 40—Effect of variations in chromate ion concentration of oxygen-free N/10 KCl solution at pH=8.0. 2 mm<sup>2</sup>—Puro electrode. G. K<sub>2</sub>CrO<sub>4</sub> per liter: No. 42—0; No. 47—0.4853; No. 58—33.9696.

tive potentials with increasing chromate concentration. Curve 28, which was obtained with 4.8528 grams of K<sub>2</sub>CrO<sub>4</sub> per liter of the N/10 K<sub>2</sub>SO<sub>4</sub> solution, indicates the formation of an anodic film which prevented the flow of a significant anodic current until a potential of -0.21 volt was reached. The shape of this curve indicates a tendency toward alternate formation and destruction of a protective anodic layer, a point which has already been discussed. In this case it appears conditions were not quite right for obtaining repeated fluctuations observed by some investigators, notably by Hedges. When the hydrogen ion concentration of the N/10 K<sub>2</sub>SO<sub>4</sub> solution was reduced further, to a value corresponding to a pH of 8.0, the current-potential curves presented in Figure 36 were obtained. With chromate ions absent, the pure iron electrode became anodic at a potential of -0.78 volt, and the current thereafter increased in the positive direction in a manner indicating an essentially unhindered primary anodic reaction. With 0.4853 gram per liter of K<sub>2</sub>CrO<sub>4</sub> in the solution, the anodic current reached 4 microamperes only when the potential had attained a value of -0.16 volt. At this point an additional change in the applied emf, instead of making the anode still more positive,

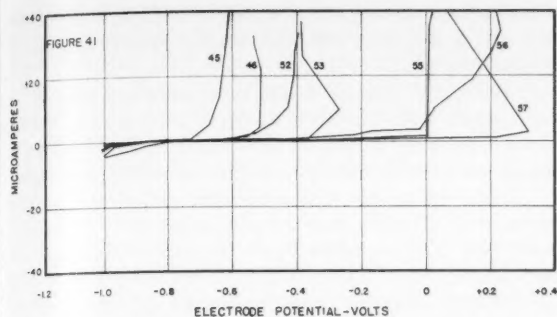


Figure 41—Effect of variations in the chromate ion concentration of oxygen-free N/10 KCl solution at pH = 10.0. 2 mm<sup>2</sup> = Puro electrode. G. K<sub>2</sub>CrO<sub>4</sub> per liter: No. 45—0; No. 46—0.4853; No. 52—0.9706; No. 53—9.7056; No. 55—19.4112; No. 56—24.2640; No. 57—33.9696.

caused the anodic film to break down. The current then increased rapidly to 49 microamperes as the potential spontaneously shifted back to a value of -0.585 volt.\* After destruction of the anodic film as indicated by the spontaneous changes in current and potential, the experimental data indicate an uninhibited primary anodic reaction, at least up to a current of 100 microamperes. Curve 35 in Figure 36 was obtained with 4.8528 grams of K<sub>2</sub>CrO<sub>4</sub> per liter of N/10 K<sub>2</sub>SO<sub>4</sub> solution. In this case the anodic current increased gradually as the electrode potential became more positive, and reached a value of 8 microamperes at +0.40 volt. Beyond +0.40 volt the current continues to increase, although somewhat more rapidly, until oxygen evolution potentials were reached when it rose rapidly. This curve is interpreted as showing the formation of an anodic film, which, however, was not completely protective. It may be that forces tending to destroy this film become greater as the potential becomes more positive, so that a gradually increasing anodic current must flow to maintain the anodic film.

The curves in Figures 37 to 41, inclusive, were obtained in an experiment that was similar to the one just described except that the supporting electrolyte was N/10 KCl instead of N/10 K<sub>2</sub>SO<sub>4</sub>, and a much higher concentration of K<sub>2</sub>CrO<sub>4</sub> was used in one group of the solution. These tests were made with a 2-mm<sup>2</sup> Puro electrode in oxygen-free N/10 KCl solution ranging in pH from 2 to 10, and in K<sub>2</sub>CrO<sub>4</sub> concentration from 0 to 33.9696 grams per liter.

A characteristic effect of the chromate in both K<sub>2</sub>SO<sub>4</sub> and KCl solutions appears to be to displace in a positive direction, the potential at which the electrode becomes anodic, i.e., the current becomes positive. The magnitude of this shift is related directly to the chromate concentration, but is not a linear function thereof. The curves in Figures 37 to 41, inclusive, illustrate this point, but it is more apparent at the lower pH levels because of the shape of the curves. At a pH of 2.0, the curves in Figure 37 indicate that as much as 33.9696 grams of K<sub>2</sub>CrO<sub>4</sub> per liter had no significant effect upon the primary anodic reaction which results in the disappearance of metal atoms (or ions) from the metal lattice, and their appearance in the solution as ions. Above +10 micro-

amperes, the anodic current curves for the three concentrations of K<sub>2</sub>CrO<sub>4</sub>, namely, 0, 0.4853, and 33.9696 grams per liter, may be considered identical within experimental limits. The experimental data presented in the form of current-potential curves in Figure 38 were obtained with oxygen-free N/10 KCl solutions adjusted to pH 4.0 and containing 0, 0.4853, and 33.9696 grams of K<sub>2</sub>CrO<sub>4</sub> per liter. In the absence of chromate, a normal anodic current curve (No. 43) indicates the anodic reaction was essentially unhindered. Curves 49 and 60 do not bear the same relationship to each other in the anodic current region that would be expected on the basis of other measurements, with the K<sub>2</sub>SO<sub>4</sub> solutions for example. The fact that between 0 and 30 microamperes, the anodic curve (No. 49) for the solution containing 0.4853 gram of K<sub>2</sub>CrO<sub>4</sub> per liter occurs at about a 0.11-volt more positive potential than does the curve for the solution with 70 times as much chromate, cannot be explained. This, and the decrease in the anodic current between -0.525 and -0.421 volt in curve 60, may be the result of some unusual condition of the electrode.\* It should be pointed out, however, that if the irregularities in the anodic curves were the result of abnormal electrode conditions, apparently they had no significant effect upon either the cathodic currents, or the potential values for zero current. At pH 6.0, the three curves, No. 41, 48, and 59, in Figure 39 were obtained at K<sub>2</sub>CrO<sub>4</sub> concentrations of 0, 0.4853, and 33.9696 grams per liter, respectively. Anodic curves for these three chromate concentrations are identical in shape but occur at successively more positive potentials. The curve for 0.4853 gram K<sub>2</sub>CrO<sub>4</sub> per liter is about 0.10 volt more positive than the curve for the chromate-free solution. Similarly there is about a 0.13-volt difference between the curves for the solutions containing 0.4853 and 33.9696 grams of K<sub>2</sub>CrO<sub>4</sub> per liter. On increasing the pH of the oxygen-free N/10 KCl electrolyte from 6.0 to 8.0, which is equivalent to a hundredfold decrease in the hydrogen ion concentration, the anodic current curves for the solutions containing 0 and 0.4853 grams of K<sub>2</sub>CrO<sub>4</sub> per liter were unchanged. Compare curves 41 and 48 in Figure 39 with curves 42 and 47 in Figure 40.

Only at a concentration of 33.9696 grams of K<sub>2</sub>CrO<sub>4</sub> per liter was the anodic current curve drastically changed by this hundredfold decrease in hydrogen ion concentration. Magnitude of this change can be seen by comparing curve 59 in Figure 39 with curve 58 in Figure 40. At pH 8.0 in oxygen-free N/10 KCl solution containing 33.9696 grams of K<sub>2</sub>CrO<sub>4</sub> per liter, the Puro electrode became anodic at a potential of about -0.70 volt (Curve 58, Figure 40). However, the anodic current remained low, less than one microampere, until the potential reached a value of about 0 volt, and then increased at a moderate rate. The data thus indicate the formation of a protective layer on the surface of the iron electrode. At a potential of 0 volt, this film began to lose its protective value and the current increased. Between 40 and 100

\* This irregularity was not considered of sufficient importance to justify a repetition of the experiments involved, inasmuch as the effect of variations in chromate ion concentration is unquestionably established by the other data presented in this section.

\* This point is not shown in Figure 36.



microamperes the current-potential curve for this solution was practically a straight vertical line.

The seven curves in Figure 41 were obtained with a 2-mm<sup>2</sup> Puron electrode in oxygen-free N/10 KCl solutions adjusted to pH = 10.0 and containing seven different concentrations of K<sub>2</sub>CrO<sub>4</sub> ranging from 0 to 33.9696 grams per liter. These anodic current curves, while showing some irregularity, exhibit an unmistakable shift to more positive potentials with increasing chromate concentration. At this low hydrogen ion concentration, protective anodic films were formed at K<sub>2</sub>CrO<sub>4</sub> concentrations equal to and greater than 9.7056 grams per liter.

In concluding this section on the effect of variations in chromate concentration upon the anodic behavior of a pure iron electrode, the following points deserve emphasis. In both K<sub>2</sub>SO<sub>4</sub> and KCl solutions the ability of chromate ions to produce a protective film on the surface of an iron electrode by anodic polarization decreased with increasing hydrogen ion concentration of the solution; while at constant pH it increased with increasing chromate concentration. Below certain limiting values of pH, the first additions of chromate had no appreciable influence upon the anodic current-potential curves.

A very much higher chromate concentration was required to produce anodic films in KCl than in K<sub>2</sub>SO<sub>4</sub> solutions of the same hydrogen ion concentration. For example, at pH 8.0 a more stable protective film was produced on the iron electrode in N/10 K<sub>2</sub>SO<sub>4</sub> by 4.8528 grams per liter of K<sub>2</sub>CrO<sub>4</sub>, than was produced by 33.9696 grams of K<sub>2</sub>CrO<sub>4</sub> per liter in N/10 KCl. This is a chromate concentration ratio greater than 1 to 7.

### III—Anodic Passivity Versus Current Density in Various Aqueous Solutions

According to the literature it should be possible to anodically polarize a metal electrode in almost any solution, no matter how corrosive, by raising the anodic current density to a sufficiently high value. For example, Glasstone<sup>6</sup> quotes some experimental work in which iron in N sulfuric acid solution became passive at a current density of 289 milliamperes per cm<sup>2</sup> in 12.4 seconds. The fact time also is a factor in determining anodic passivity was shown by a

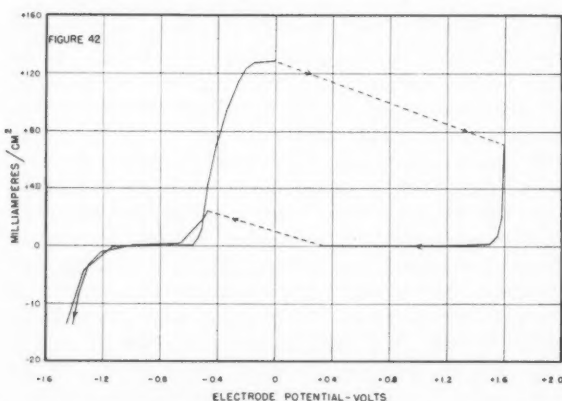


Figure 42—Electrolysis of air-saturated N/10 K<sub>2</sub>SO<sub>4</sub> solution at pH = 6.0. 2 mm<sup>2</sup> = Puron electrode.

second test. At a current density of 15 milliamperes per cm<sup>2</sup> it required 848 seconds to passivate iron in N sulfuric acid.

A few experiments of this type were carried out in connection with this investigation. Pure iron (Puron) electrodes were used, and the current-potential measurements were started at some point on the hydrogen evolution curve, that is, with the iron acting as the cathode at a sufficiently negative potential to evolve hydrogen by the electrolysis of water. The applied emf was changed by small increments so the potential of the test electrode was increased gradually from around -1.2 volts to +1.6 volts, and then decreased in the same manner to -1.2 volts. The potential of the electrode and the cell current were measured at each value of the applied emf. The average time between successive changes in emf was about 3½ minutes. The time factor, whose effect was indicated above to be very marked, was not under systematic control in these experiments.

In discussing graphs in this section of the report the term "forward" and "backward" will be used to refer to the curves obtained with increasing (from negative to positive) and decreasing (from positive to negative) electrode potentials, respectively. In those cases in which the forward and backward curves were different, their direction has been indicated by means of arrows. Where the two were identical, it was considered unnecessary to distinguish between them.

The current density-electrode potential curve in Figure 42 was obtained with a 2-mm<sup>2</sup> Puron electrode in air-saturated N/10 K<sub>2</sub>SO<sub>4</sub> solution at pH = 6.0.\* This experiment was started with an applied emf which gave the electrode a potential of -1.45 volts. Current at this cathodic potential, 13.7 milliamperes per cm<sup>2</sup> was consumed in evolving hydrogen by the electrolysis of water. As the potential of the electrode was increased, i.e., became more positive, the cathodic current density decreased rapidly to zero, because at pH 6.0 the hydrogen ion concentration is too low to support an appreciable current under these conditions. However, in this air-saturated solution, some cathodic current should flow between -1.0 and -0.7 volt as a result of the reduction of oxygen. This is indicated in Figure 12. Data for this experiment show an oxygen reduction current of about 2 microamperes, a value which is in agreement with the data in Figure 12, but which amounts to only 0.10 milliamperes per cm<sup>2</sup> when plotted in Figure 42.

At a potential of about -0.6 volt the electrode became anodic, and the current density increased rapidly in the positive direction. This branch of the curve has been termed the normal corrosion curve resulting from, or accompanying the uninhibited dissolution of the iron anode. It will be noted that as the anodic current density increased, the slope of the curve fell off with increasing rapidity, and finally, at a value of 128 milliamperes per cm<sup>2</sup> was almost zero. This behavior is believed to be due to the rapidly increasing concentration of the anodic reaction product Fe<sup>2+</sup> in the solution in contact with the electrode. This

\* This was the unadjusted pH of the solution.

would lead to a form of concentration polarization resulting in a limiting or diffusion current. Figure 42 clearly shows the beginning of this diffusion current. However, at this high current density insoluble corrosion products were being precipitated in such close proximity to the electrode surface they soon formed a protective anodic film. This occurred at a potential of 0 volt. It was found at this point in the experiment, that a change in the applied emf which should have increased the potential from 0 to about +0.1 volt actually shifted it to +1.6 volts; and the current density, which should have remained unchanged, dropped to about 71 milliamperes per  $\text{cm}^2$ . These latter values represent a point on the oxygen evolution curve, indicating the cell current was being used in the electrolysis of water with the evolution of oxygen at the anode surface.

The backward curve was begun at a potential of +1.6 volts. It represents an attempt to retrace the forward curve by gradually returning the potential of the electrode to its original or starting value. As the potential decreased (i.e. became less positive) from +1.6 volts, the current density fell off rapidly to zero as the evolution of oxygen decreased to zero.

The applied emf was not great enough to electrolyze water at an anode potential of +1.2 volts, therefore, at this potential the current density was practically zero. Furthermore, the electrode still was anodically polarized so the electrode reaction  $\text{Fe} \rightarrow \text{Fe}^{++} + 2e$  could not proceed. A slight change in potential beyond +0.35 volt on the backward curve suddenly shifted the value to -0.47 volt, and the current density increased from 0 to 25 milliamperes per  $\text{cm}^2$ . These spontaneous changes in both the backward and forward curves are indicated by dashed lines in the graphs. This "break" in the backward curve is believed to be due to the sudden destruction of the protective anodic layer or film.

With the electrode no longer anodically polarized, the potential and current density assumed values on or close to the normal anodic current curve. From this point on, the backward curve was essentially the same as the forward curve. Some difference would be expected, however, because the electrode surface was different due to corrosion. This test was begun with a highly polished electrode surface, and was ended with the surface looking, at 60X, very much like the surface of a sponge. Most of this corrosion occurred along the normal anodic current portion of the forward curve.

On the basis of the anodic polarization data quoted from Glasstone for iron in N sulfuric acid, it also would be expected a time factor influencing the results obtained in N/10  $\text{K}_2\text{SO}_4$  would be found. Although no experiments were conducted to verify this point, the time required to achieve a state of anodic polarization should decrease with increasing anodic current density. Thus in Figure 42, if the time between each of the successive steps on the normal anodic current portion of the curve had been 15 instead of 3 to 4 minutes, anodic polarization should have occurred at a lower current density than 128 milliamperes per  $\text{cm}^2$ .

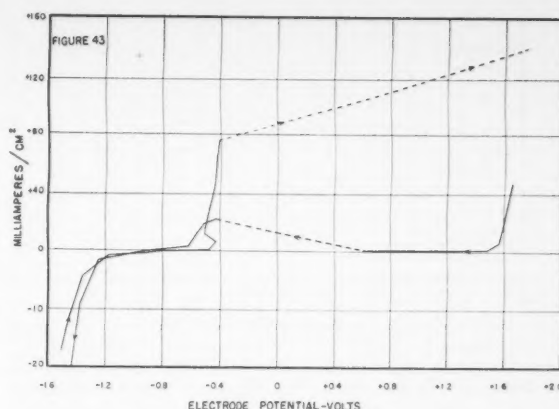


Figure 43—Electrolysis of air-saturated N/10  $\text{K}_2\text{SO}_4$  solution containing 2.4264 g.  $\text{K}_2\text{CrO}_4$  per liter at pH = 8.3. 2 mm<sup>2</sup> = Puron electrode.

Anodic polarization or passivity begins to set in when the solution in the immediate vicinity of the electrode becomes saturated with the anodic reaction product, and a solid salt is precipitated on the anode surface. This eventually results in the formation of a thin invisible, but highly protective oxide film on the metal surface. The process by which this final protective layer is formed will be discussed later in some detail. For the moment it is sufficient to know the first stage occurs when that portion of the solution in contact with the electrode becomes saturated with the anodic reaction product.

Thus, any solution constituents which tend to decrease the solubility of the products, or to react with them to produce less soluble materials, would make it easier to achieve the state of anodic passivity. In the case of iron, the products being less soluble in alkaline than in acid solutions, passivity would be favored by an increase in pH.

Anodic passivity would be expected to occur at lower current densities in the presence of oxidizing agents such as soluble chromates and dissolved oxygen, because of their ability to produce the more insoluble ferric salts.

Of course, anything which would tend to prevent the deposition of solid products on the anodic surface would hinder anodic polarization. An increase in temperature (by increasing solubility), stirring of the solution, etc., would have this effect.

The above discussion should lead to a better understanding of the significance of the following current density-electrode potential curves. Figure 43 was obtained with a Puron electrode in an air-saturated N/10  $\text{K}_2\text{SO}_4$  solution containing 2.4264 grams of  $\text{K}_2\text{CrO}_4$  per liter at pH 8.3.\* Most significant result of this test is that anodic polarization set in at an appreciably lower current-density, 76 milliamperes per  $\text{cm}^2$ , as compared with a value of 128 for the chromate-free solution at pH 6.0. This difference illustrates the combined effect of the increase in pH and the addition of the chromate.

Figures 44 to 47, inclusive, show the effect of variations in the hydrogen ion concentration of air-satu-

\* This was the unadjusted pH of the test solution.

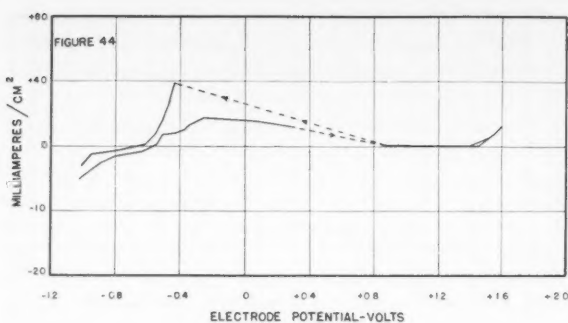


Figure 44—Electrolysis of air-saturated N/10  $K_2SO_4$  solution containing 4.8528 g.  $K_2CrO_4$  per liter at pH = 2.0. 2 mm<sup>2</sup>—Puron electrode.

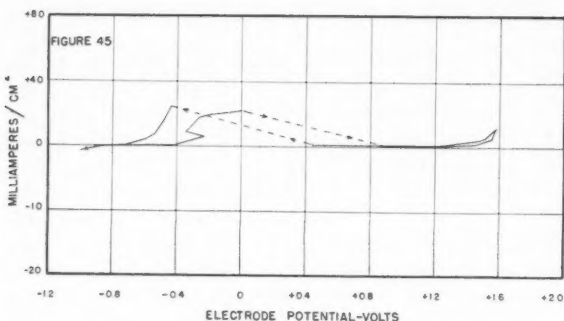


Figure 45—Electrolysis of air-saturated N/10  $K_2SO_4$  solution containing 4.8528 g.  $K_2CrO_4$  per liter at pH = 4.0. 2 mm<sup>2</sup>—Puron electrode.

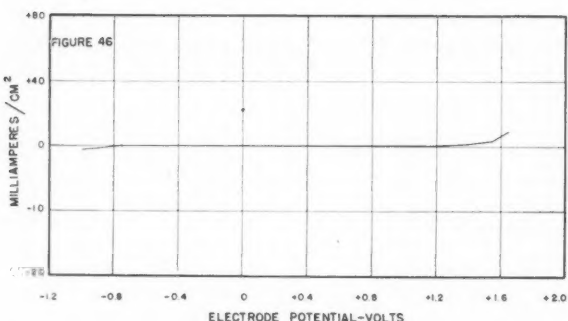


Figure 46—Electrolysis of air-saturated N/10  $K_2SO_4$  solution containing 4.8528 g.  $K_2CrO_4$  per liter at pH = 6.0. 2 mm<sup>2</sup>—Puron electrode.

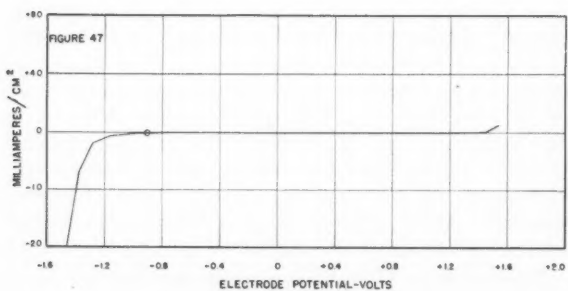


Figure 47—Electrolysis of air-saturated N/10  $K_2SO_4$  solution containing 4.8528 g.  $K_2CrO_4$  per liter at pH = 8.0. 2 mm<sup>2</sup>—Puron electrode.

rated N/10  $K_2SO_4$  solutions containing 4.8528 grams of  $K_2CrO_4$  per liter. This is a higher chromate ion concentration than should have been used to best illustrate the effect of pH variations. At pH 2.0 (Figure 44), the electrode became anodic at a potential of  $-0.57$  volt, but the anodic current density did not, thereafter, increase rapidly along the normal corrosion curve. Instead, it rose slowly to a value of 17 milliamperes, and then gradually fell off as the potential increased to  $+0.32$  volt. The shape of this portion of the curve can be interpreted as indicating the normal anodic reaction was being hindered by precipitation of a porous layer of reaction products. Because of the low current density, this layer thickened slowly, so the potential moved to a relatively positive value before the current density at the small unprotected areas became sufficiently high to produce the thin, transparent, and protective oxide layer, whose formation at  $+0.32$  volt, resulted in the spontaneous increase in potential to  $+0.88$  volt, and the decrease in current density to practically zero.

Current density-potential curves in Figure 45 were obtained at a hydrogen ion concentration corresponding to pH 4.0. They differ but little from those shown in Figure 44 for the same solution at pH 2.0. Actually a higher current density (22 milliamperes per cm<sup>2</sup>) was reached before anodic passivity set in with the pH 4.0 solution than with the pH 2.0 solution (17 milliamperes per cm<sup>2</sup>). A difference in the opposite direction would be expected, although the effect of pH differences on the solubility of the reaction products may not be very marked in this pH range.

With a further increase in the pH of the solution, from 4.0 to 6.0, anodic passivity set in at practically zero current density. The only anodic current that flowed during this experiment was that which accompanied the evolution of oxygen due to the electrolysis of water. This is shown by the gradual rise beginning at about  $+1.1$  volt and extending to  $+1.65$  volts. The backward and forward curves were identical in this experiment.

Identical current density-potential curves were obtained at pH values of 6.0 and 8.0 with air-saturated N/10  $K_2SO_4$  solutions containing 4.8528 grams of  $K_2CrO_4$  per liter. This may be seen readily by comparing Figures 46 and 47. These two figures indicate a point appropriately emphasized here. Although identical curves were obtained with these two solutions, there can be little doubt the pH 8.0 solution had greater "inhibitive power" than the same solution at pH 6.0. This is indicated by the fact this type of curve would be obtained at lower chromate ion concentrations at pH 8.0, than would be possible at pH 6.0. However, experimental data in Figures 46 and 47 fail to show this difference. Hence, it must be concluded that current or current density-potential data cannot be used directly to evaluate the "inhibitive power" of inhibitive solutions, although indirectly, much information about them can be gained by such measurements, provided they are extended to include the effect of some other variable such as pH.



Curves in Figure 48 were obtained with a 2-mm<sup>2</sup> Puron electrode in an air-saturated N/10 K<sub>2</sub>SO<sub>4</sub> solution containing 6.9095 grams of K<sub>2</sub>CO<sub>3</sub> per liter (M/20) at a hydrogen ion concentration corresponding to pH 11.2. Effect of this relatively high concentration of hydroxyl ions is seen readily by comparing Figures 42 and 48. There was a definite reduction in the current density (from 128 to 56 milliamperes per cm<sup>2</sup>) at which anodic polarization occurred, when the pH of the N/10 K<sub>2</sub>SO<sub>4</sub> solution was increased from 6.0 to 11.3. Approximately the same effect was obtained by adding 2.4264 grams of K<sub>2</sub>CrO<sub>4</sub> per liter and increasing the pH to 8.3 (see Figure 43).

When twice as much K<sub>2</sub>CO<sub>3</sub> (13.8190 grams per liter M/10) was added to the N/10 K<sub>2</sub>SO<sub>4</sub> solution, anodic polarization set in at, and was maintained by a very low current density, as shown in Figure 49. In this case the anodic current density did not rise above 1.5 milliamperes per cm<sup>2</sup> until the region of oxygen evolution was reached. It is interesting to note that although the additional K<sub>2</sub>CO<sub>3</sub> used in obtaining the data in Figure 49 had a marked effect on the current density-potential curves, it had very little effect upon the pH of the solution. The change in K<sub>2</sub>CO<sub>3</sub> concentration from 0.05 to 0.10 M increased the pH of the solution from 11.2 to 11.3. This would indicate the difference between Figures 48 and 49, i.e., between 6.9095 and 13.8190 grams of K<sub>2</sub>CO<sub>3</sub> per liter, was the result not of a pH change, but of the increase in carbonate ion concentration.

Initial screening of the electrode might, in this case, have resulted from the precipitation of a carbonate, probably a basic ferrous carbonate. The curves in Figures 48 and 49 show the polarity of the cell current changed from negative to positive at potentials between -0.9 and -1.0 volt. This is a very unusual potential at which to find the electrode shifting from the cathodic to the anodic state, and its significance is not understood fully at present.

### Discussion

By application of polarographic methods and with the aid of a specially constructed cell it was possible to study the effects of different concentrations of hydrogen ion, dissolved oxygen and potassium chromate in aqueous solutions of potassium chloride and potassium sulfate on the current-potential curves obtained with a Puron electrode. Results show hydrogen ions are reduced readily at a pure iron cathode at potentials that would obtain during normal corrosion of this metal. Cathodic current was found to be approximately proportional to the hydrogen ion concentration of the solution. This was to be expected but it serves to emphasize the importance of the pH of corrosive solutions. For example, if the anode is capable of being oxidized at an unlimited rate and other factors remain constant while the hydrogen ion concentration of a corrosive solution is varied, corrosion would increase tenfold for each one-unit decrease in pH. It also becomes easy to understand why the corrosion rate of iron or steel in neutral oxygen-free water is so very low. It is limited by the scarcity of an electroreducible

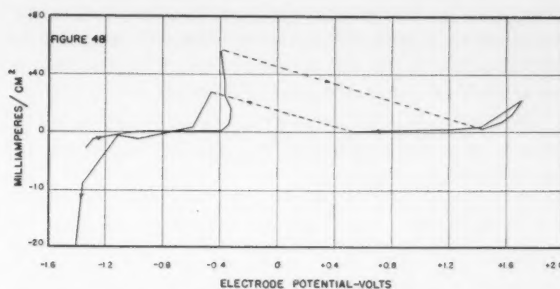


Figure 48—Electrolysis of air-saturated N/10 K<sub>2</sub>SO<sub>4</sub> solution containing 6.9095 g. K<sub>2</sub>CrO<sub>4</sub> per liter at pH = 11.2. 2 mm<sup>2</sup> = Puron electrode.

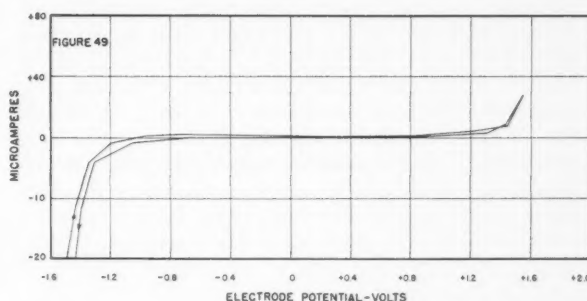
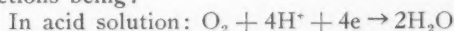


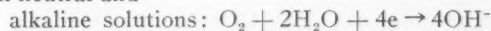
Figure 49—Electrolysis of air-saturated N/10 K<sub>2</sub>SO<sub>4</sub> solution containing 13.8190 g. K<sub>2</sub>CrO<sub>4</sub> per liter at pH = 11.3. 2 mm<sup>2</sup> = Puron electrode.

material since at pH 7 the hydrogen ion concentration is only 0.0000001 mole per liter.

Oxygen is not necessary for the corrosion of iron and steel, although in most natural waters it is the most important cathodic depolarizer because the hydrogen ion concentration is too low to support much current. According to Kolthoff and Lingane<sup>1</sup> the electrolytic reduction of dissolved oxygen proceeds in two stages, hydrogen peroxide being produced in the first stage in both acid and alkaline solutions. In the second stage the hydrogen peroxide is reduced to water in acid solutions, and to hydroxyl ions in neutral and alkaline solutions. The net reactions being:



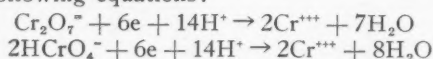
In neutral and



In N/10 KCl solution at pH 6.0 the cathodic current resulting from the reduction of dissolved oxygen at a Puron electrode was found to be directly proportional to the oxygen concentration. At a potential of -0.80 volt, this current amounted to about one microampere for the air-saturated solutions containing about  $2.5 \times 10^{-4}$  moles of oxygen per liter, and was independent of pH between the limits of 4.0 and 10.0. At pH 2.0, however, the apparent oxygen reduction current was 13 microamperes at a potential of -0.8 volt. This phenomenon has not been yet satisfactorily explained, largely because of an insufficiency of experimental data. It should be pointed out that although the former equation is given for acid, and the latter for alkaline solutions, the second reaction should occur in acid solutions as well, under experimental conditions used in this investigation. This

conclusion is based on the fact the solution in immediate contact with the cathode would be alkaline by virtue of the reduction of all of the hydrogen ions as soon as they reach the cathode surface.

Under certain conditions, chromate ions can be reduced at an iron cathode, presumably according to the following equations:



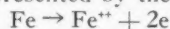
Experimental data seem to indicate the third chromate ion species,  $\text{CrO}_4^{2-}$ , is not reduced directly. From published equilibrium constants, relative concentrations of the three species of chromate ion ( $\text{CrO}_4^{2-}$ ,  $\text{HCrO}_4^-$ , and  $\text{Cr}_2\text{O}_7^{2-}$ ) were calculated for solutions ranging in total potassium chromate concentration from 0.001 to 1.0 molar, and in pH from 2.0 to 10.0 in order to facilitate an explanation of the experimental results, which indicate chromate ions were reduced at a significant rate only when the hydrogen ion concentration of the solution was greater than 0.0001 mole per liter (pH 4.0). For example, the cathodic currents associated with chromate reduction at  $-0.8$  volt were 82, 17, 3, and 1 microamperes for KCl solutions containing 0.4853 grams of  $\text{K}_2\text{CrO}_4$  per liter at pH values of 2, 2.5, 3, and 3.5, respectively.

Calculations have shown that between pH 2 and pH 4 there is no significant change in relative concentrations of the three kinds of chromate ion. In this pH range, the chromate in a M/100  $\text{K}_2\text{CrO}_4$  solution would be present in the form and relative proportions of 1  $\text{CrO}_4^{2-}$  to 32,000  $\text{HCrO}_4^-$  to 9,000  $\text{Cr}_2\text{O}_7^{2-}$ . It cannot be stated conclusively that  $\text{CrO}_4^{2-}$  was not reduced in these experiments, but it can be said it was present only in very small amounts when significant cathodic reduction of chromate occurred, i.e., between pH 2 and pH 4.

Equations given for the electrolytic reduction of chromate ions do not explain satisfactorily the observed experimental data, since the same number of electrons would be exchanged in the reduction of the same number of hydrogen ions whether the chromate was present or not. That is, since the electron exchange is the same for a given amount of hydrogen ion reduction whether chromate is present or not, one would expect the cathodic current to be the same also. This, however, was not the case. The presence of chromate increased the cathodic current by an amount directly proportional to the chromate concentration, but only when the hydrogen ion concentration exceeded 0.0001 M (pH 4.0).

The two "indifferent" salts KCl and  $\text{K}_2\text{SO}_4$  used as supporting electrolytes in these experiments had no direct effect upon the cathodic currents obtained with a Puron electrode because none of their ions is reduced at the potentials employed. Nor did either of them have any effect upon the primary anodic reaction. Their indirect effect through secondary reactions, however, is important and will be discussed later.

Since the primary anodic reaction in these experiments may be represented by the equation



its rate would not be expected to be greatly affected by variations in either hydrogen ion or dissolved oxygen concentration. An effect of these variables was found, however, in the potential at which the polarity of the cell current reversed and the Puron electrode became anodic. This potential became increasingly positive as the hydrogen ion concentration increased, and this effect generally was greater for the pH change from 2 to 4 than for a two-unit change at higher pH levels. A study of all of the experimental data seems to indicate the magnitude of this shift in the potential at which the electrode became anodic was some function of the magnitude of the cathodic current that flowed prior to the change. The displacement appeared to be greater when the solution contained sufficient electroreducible material to yield a cathodic current of some magnitude.

Shape of the anodic current curve was unaffected by variations in hydrogen ion concentration, although as already mentioned, the curves generally were shifted to more positive potentials by decreasing the pH of the solution. This would indicate a decrease in the rate of the anode reaction with increasing hydrogen ion concentration. At pH values above 4 the curves usually were identical within experimental limits. For example, at a potential of  $-0.65$  volt in oxygen-free N/10 KCl the Puron electrode was anodic and corroding freely at pH values from 4 to 10, but at pH 2 in the same solution it still was cathodic and discharging hydrogen ions.

Effect of variations in dissolved oxygen concentration of the electrolyte upon the anodic current curves obtained with a Puron electrode, was qualitatively the same as the effect of variations in hydrogen ion concentration. Increasing the oxygen concentration shifted the anodic current curves bodily to more positive potentials. Magnitude of the effect is indicated by the fact the potentials at which the electrode became anodic were  $-0.78$ ,  $-0.69$ , and  $-0.65$  volt for solutions containing O, 0.00025, and 0.001 mole per liter of oxygen, respectively. Thus at a potential of  $-0.7$  volt the Puron electrode was anodic and corroding when the N/10 KCl solution contained no oxygen, but was still cathodic at this potential when the same solution was saturated with oxygen. It is concluded, therefore, the effect of dissolved oxygen is to decrease the rate of the primary anodic reaction  $\text{Fe} \rightarrow \text{Fe}^{2+} + 2e$ , and that the effect is essentially independent of the pH of the solution.

No evidence has been uncovered which would indicate that partial or complete inhibition of the primary anodic reaction (corrosion) is not due to formation of a physical barrier on the electrode surface. It is true that under the conditions of these experiments, a degree of concentration polarization could be set up at the small Puron anode which would shift the potential in the positive direction. The experimental data, however, show no evidence anodic concentration polarization was responsible for any significant deviation of the anodic current curve from its normal position for unhindered corrosion. Deviations which did occur therefore will be treated as

though resulting from a physical barrier of some primary or secondary reaction product.

A great deal could be written about the nature of the protective anodic film which is presumed to be formed on the surface of iron in the presence of an adequate concentration of chromate ions, but this already has been the subject of much of the literature on corrosion. It is sufficient for the immediate purposes of this investigation to take the view that chromate ions tend to produce, or facilitate the production of an exceedingly thin, insoluble and protective coating on iron and steel surface. Whether or not such protective films will form in a given solution containing chromate ions depends upon a number of properties of the test solution. A number of these were studied in the course of this investigation, and the following conclusions were derived from the experimental data.

The protective action of chromate ions is hindered by certain otherwise indifferent anions such as sulfate and chloride. For example, at pH 8.0 a more stable protective film was produced on the iron electrode in N/10  $K_2SO_4$  solution by 4.8528 grams per liter of  $K_2CrO_4$  than was obtained in N/10 KCl solution with 33.9696 grams per liter of  $K_2CrO_4$ . This represents a chromate concentration ratio greater than 1 to 7, and indicates how much less effective chromate is in the presence of chlorides than in the presence of sulfates.

Anodic current curves presented in this article show the effect of pH variations in the presence of different amounts of potassium chromate. It was demonstrated that the lower the pH of the solution, i.e., the higher its hydrogen ion concentration, the greater was the amount of potassium chromate needed to cause anodic polarization. With 0.4853 gram (0.0025 mole) of  $K_2CrO_4$  per liter of N/10  $K_2SO_4$  solution there was evidence of anodic film formation at pH 8.0 but not at pH 6.0. A tenfold increase in  $K_2CrO_4$  (to 4.8528 grams or 0.025 mole per liter) resulted in some anodic polarization at pH 6.0, a hundredfold higher critical hydrogen ion concentration.

Similar results were obtained with KCl instead of  $K_2SO_4$  solutions except that with KCl much higher concentrations of  $K_2CrO_4$  were required before anodic polarization occurred even at pH 10.0.

Anodic current-potential curves indicate that in the presence of chromate ions, dissolved oxygen assisted in formation of protective anodic films. Films formed under similar conditions were more stable when oxygen was present than when it was absent. In other words, anodic films were formed under more adverse conditions, e.g., higher hydrogen ion concentration, when the solutions contained oxygen than when they did not.

Some experiments were carried out to determine whether an iron electrode could be forced into a state of anodic polarization in relatively corrosive solutions. It was found to be possible to do this if the anodic current density was increased to a sufficiently high value. The experimental data indicate that under controlled conditions magnitude of the current density required to polarize the anode affords a measure of the corrosiveness of the solution. The higher this value, the more corrosive the solution. For example, anodic polarization set in at a current density of 128 milliamperes per  $cm^2$  in an air-saturated, N/10  $K_2SO_4$  solution at pH 6.0. On increasing the pH to 8.3 and adding 2.4264 grams (0.0125 mole) of  $K_2CrO_4$  per liter, the polarizing current density dropped to 76 milliamperes per  $cm^2$ . And with 4.8528 grams (0.025 mole) of  $K_2CrO_4$  per liter at pH 6.0 anodic polarization set in before there was a measurable flow of current.

In these experiments the attainment of a state of anodic polarization was indicated by a sudden and spontaneous shift in the potential of the electrode to a much more positive value—usually to one sufficiently positive to evolve oxygen by the electrolysis of water.

With an air-saturated N/10  $K_2SO_4$  solution containing 6.91 grams of  $K_2CO_3$  per liter, anodic polarization occurred when the current density reached 58 milliamperes per  $cm^2$ . When the  $K_2CO_3$  concentration of this solution was doubled (13.82 grams per liter) the anodic current density did not exceed 2 milliamperes per  $cm^2$  until the region of oxygen evolution was reached, indicating the ease of anodic polarization under these conditions.

#### Acknowledgment

This investigation was conducted in the laboratories of The New Jersey Zinc Company (of Pa.) under contract with the Research Section, Bureau of Ships, U. S. Navy Department. The generous assistance given by various members of the staffs of these two organizations and permission to publish this paper are gratefully acknowledged.

#### References

1. Kolthoff, I. M., and Lingane, J. J., *Polarography*, Interscience Publishers, Inc., Pg. 435 (1941).
2. *Ibid.*, Pg. 442.
3. *Ibid.*, Pg. 307.
4. Neuss, J. D., and Rieman, W., *J. Am. Chem. Soc.* **56**, 2238 (1934).
5. Hodges, E. S., *Protective Films on Metals*, Chapman & Hall, Ltd. (1932).
6. Glasstone, Samuel, *An Introduction to Electrochemistry*, D. Van Nostrand Company (1942).





# Topic of the Month

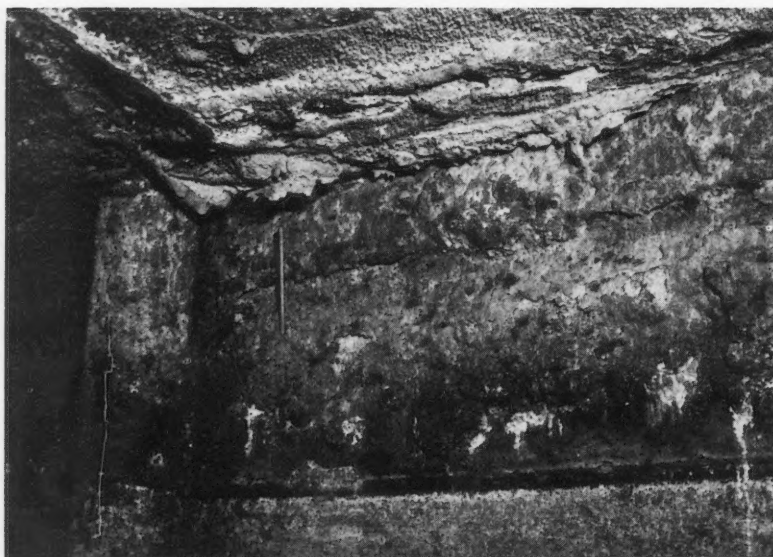


Figure 1.

Showing the corrosion products cumulated in the vapor space of the tank roof during the forty months of service.

Vapor space starting at the black line.

Note the reflections of the free sulfur and salts.

Analysis of corrosion product next to the steel:

Iron percent by weight	61.49%
Total sulfur by weight	5.97%

Free sulfur	5.00%
Sulphate sulfur	.97%

Analysis corrosion product next to vapor space:

Iron percent by weight	24.61%
Sulfur by weight	61.43%

Free sulfur	60.66%
Sulphate sulfur	.77%

No iron sulphide (FeS) detected.

## Corrosion in Sour Crude Storage Tanks

By DERK HOLSTEYN\*



Figure 2.

Same area as shown in Figure 1 with some of the corrosion products removed.

After sandblasting penetrations were revealed.

\*Engineer, Shell Oil Co., Inc., Houston, Texas.



# NACE News

## New Sections Are Being Organized

Southeast Region's meeting March 15 was held at Atlanta, Ga. For the first time all regional NACE officers were present for the meeting.

Attendance at discussion sessions which began at 10 a.m. was 45, while 54 were present for the dinner, which was held jointly with the American Society of Metals. Inability of some who were present for the daytime sessions to attend the dinner caused the relatively small difference in numbers between the NACE meetings and the joint dinner session. Present for dinner were 32 NACE members and 22 ASM members.

Following is the day's program: 10 a.m.—Registration. 10:30 a.m.—Introductory remarks by E. C. Range, chairman. 10:45 a.m.—Brief discussion of corrosion fundamentals, by Dr. Ivy M. Parker. 11:00 a.m.—"Copper Pipe Corrosion in Atlanta Water," by A. T. Storey. 11:30 a.m.—"Field Corrosion Testing in Chemical Industry," by E. P. Tait. 11:45 a.m.—"Laboratory Testing of Inhibitors," by Dr. Ivy M. Parker. 12:30 p.m.—Lunch. 2:00 p.m.—"Cathodic Protection and Electrolysis," by A. W. Peabody. 3:00 p.m.—Recess. 3:15 p.m.—Forum on Cathodic Protection and Electrolysis led by Mr. Peabody: 1. Organization of Birmingham Electrolysis Committee—Mr. Griffin. 2. Corrosion Mitigation Program of Southern Natural Gas Pipe Line Company—Jack Adams. 3. Underground Corrosion Mitigation on Southeastern Pipe Line—Mr. Van Norhuys. 4. Locating Ground Beds—J. P. McArdle. 5. Corrosion of Cast Iron—E. D. McCauley. 6:30 p.m.—Dinner. 8:00 p.m.—Address by Dr. Tom May, International Nickel Co. on various types of corrosion.

New York Section held a joint dinner meeting with the Electrochemical Society at the Building Trades Employers' Association, 2 Park Ave., N. Y., on March 10. The 88 persons present heard a very interesting talk by H. A. Humble of Dow Chemical Co., Metals Protection Laboratory, Midland, Mich., entitled "Some Observations on the Cathodic Protection of Steels and Galvanized Iron." Mr. Humble's remarks concerned cathodic protection measures developed at Kure Beach for the protection of steel in salt water and the protection of iron in hot water tanks by use of magnesium anodes. The one-hour talk was followed by a 45-minute discussion from the floor.

Of those present three were from the Midland, Mich. office and one from the Tulsa office of Dow Chemical Co.

Houston Section held its regular meeting March 16 at the Houston Engineer's Club and heard an address on "Corrosion Problems of the Electric Utilities," by Tom Keiller of Houston Lighting and Power Co.

### NACE MEMBERS

*If You Change Addresses*

*If You Change Company Affiliation*

*If You Change Positions*

Please notify the Central Office NACE, 905 Southern Standard Bldg., Houston 2, Texas, so that you will get CORROSION without delay and that association records can be kept abreast of your progress.

**THANKS!**

San Francisco Bay Area section officers have been elected as follows: Robert T. Effinger, Shell Oil Co., Inc. Martinez, Cal., chairman; Richard S. Treseder, Shell Development Co., Emeryville, Cal., vice-chairman; Arthur E. Storm, Tide-water-Associated Oil Co., Avon, Cal., secretary.

Permian Basin Section met March 23 at the Shell Building, Odessa, Texas with an attendance of 28 members and guests to hear Bob Means of The Tretolite Company talk on "Kontrol as a Corrosion Inhibitor." Following the presentation of the paper an interesting discussion followed during which results achieved with both Kontrol and formaldehyde were discussed.

Plans were discussed for the 1949 fall inspection tour calling for an expansion of last year's activity.

Western Region NACE held the second of two meetings devoted to sulfur corrosion at the Roger Young Auditorium, Los Angeles, Cal., March 30. Papers presented were "Sulfur Corrosion in Petroleum Refining," by S. J. Artese, Shell Oil Company, Long Beach, Cal.; "Corrosion of Ships' Hulls," by W. Graham, Research Engineer, Richfield Oil Company, Wilmington, Cal.; and "Sulfur Corrosion in Fuel Gas Lines," by Guy Corfield, Research Engineer, Southern California Gas Company, Los Angeles, Cal.

Present also as a panel were several men qualified to answer questions from the floor on this corrosion problem.

First region meeting devoted to aspects of sulfur corrosion dealt with the problem in water and sewage systems, and was held in February, 1949. It created considerable interest.

### Correction

Harry E. Waldrip has been named counselor of Houston Section, instead of Roy V. Comeaux as was reported in the April issue of CORROSION.

### Forty-Three Attend Beaumont Meeting

D. L. Burns, Gulf Oil Company, Port Arthur, Texas was named temporary chairman with authority to name a temporary vice-chairman and secretary of a new section in the South Central Region, organized Thursday, March 24, 1949 at a dinner meeting in Beaumont, Texas. Forty-three were present from Beaumont, Port Arthur, Neches, Lake Charles, La., Orange and Houston, Texas. There were ten members of NACE present.

Nathan Schofer, chairman of the South Central Region, who has been actively promoting the formation of a unit of the association to serve engineers and others interested in corrosion in the coastal area at the junction of the states of Texas and Louisiana in which there are numerous oil refineries, oil plants and a number of large chemical plants, opened the meeting. A. B. Campbell, executive secretary of NACE then gave a brief summary of the purposes and activities of the association, after which Lyle R. Sheppard, Houston member made a short address.

After some discussion application blanks were supplied those present of which 29 were signed and turned in.

Next meeting of the section will be held April 28 at a place to be designated. Persons in the area involved interested in corrosion are invited to attend either with the view of becoming a member of the association or participating otherwise in the section's activities.

### Pittsburgh Section Will Elect Officers

Northeast Region board has approved a petition calling for recognition of the organization of the Pittsburgh Section of the North East Regional Division of NACE. Mr. Russell H. Coe, of Pittsburgh Coke and Chemical Company, Pittsburgh, Pa., was advised by L. B. Donovan, secretary of North East Region the group now may proceed with election of officers, appointment of committees and preparation of required rules and regulations.

Cleveland Section's March 23 meeting at Hotel Allerton, Cleveland, heard C. G. Chisholm, of the Hastelloy Department of Haynes Stellite Co. present a paper titled "Hastelloy Alloys and their Use in Combating Corrosion."

**North Texas Section** held a business meeting and dinner March 31 at the Blackstone Hotel, Fort Worth, Texas, with 23 members and guests present. R. M. Dixon of the Municipal Contractors Association of Dallas spoke on "Mitigation of Corrosion in Water Distribution Systems." The talk included a review of the basic electrochemical reactions encountered in water heaters, elevated storage tanks and other structures.

**Greater St. Louis Section** held two meetings during April, one a meeting sponsored jointly with the American Institute of Chemical Engineers at the Engineer's Club, St. Louis, and the second the regular monthly meeting at the York Hotel.

At the joint meeting held April 21, W. T. Nichols, formerly of Westvaco Chemical Co., and now director of the central engineering department of Monsanto Chemical Company, St. Louis, spoke on "The Making of an Engineer."

H. O. Nordquist, of J. T. Ryerson & Sons Co., gave an illustrated talk on "Causes of Corrosion." Two sound movies, "Corrosion" and "A Heat of Stainless Steel," also were included in the program.

Four papers on various aspects of corrosion related to the petroleum industry were presented at the Houston, Texas, meeting of the division of refining, American Petroleum Institute, April 4-7.

Titles of the four papers were: "Hydrogen Blistering," by M. E. Holmberg, Phillips Petroleum Co., Bartlesville, Okla.; "Effect of Hydrogen at Elevated Temperatures," by G. W. Nelson, Shell Development Co., Emeryville, Cal.; "Corrosion of Expansion Joints," by H. F. Brown and W. M. Goryl, Standard Oil Development Co., Elizabeth, N. J., and "Cathodic Protection of Refinery Equipment," by Derk Holsteyn, Shell Oil Co., Houston, Texas.

"Science and Engineering," the official journal of the India Society of Engineers, Vol. 1, No. 6, December 1948 has been received at Central NACE office. The magazine is published at 12, Netaji Subhas Road, Calcutta, by the Bengal Autotype Co.

Engineers from seven states will be on the staff of instructors at the Fourth Annual Short Course in Gas Technology at Texas A. & I. College May 30, 31, June 1. Sponsored by Southern Gas Association, the course will cover gas conservation practices and gas technology, Dr. Frank Dotterweich, administrative committee chairman said.

## NEW PRODUCTS

### Materials—Service—Literature

**Globrite 44 and 45** are described in a new mailing piece by Globe Chemical Co., Inc., Cincinnati, Ohio. The preparations are designed to prepare metal surfaces for painting, providing a rust-resisting coating and a bond between the paint and the metal surface.

"**Tuf-On SA-14**" thermo-plastic adhesive, a product of Brooklyn Varnish Manufacturing Co., Inc., 50 Jay Street, Brooklyn 1, N. Y., is being used by the Federal Telephone and Radio Corporation, Clifton, N. J., in its dial telephone switching systems. The adhesive is applied to terminal bank insulators to preserve alignment of terminals.

**Double-purpose "Anti-Corrosion Strap Selector,"** an indexing system (composed of two circular paper discs of different diameters, fastened to rotate one over the other from a common center) with which it is possible to relate recommended types of packaging straps to selected corrosive conditions is offered by A. J. Gerrard & Co., 1950 N. Hawthorne Ave., Melrose Park, Ill. On the reverse side of the selector is a calculator to determine quantity of strapping required for any operation.

**Acid-proof Cements** manufactured by the Sauereisen Cements Co., Pittsburgh 15, Pa., are described in a new folder offered by the firm to responsible interested persons. The firm recommends the cements in corrosive environments involving acids.

**Wrought Iron's** performance in more than 100 applications in marine industry is described in a 64-page book published by A. M. Byers Co., Pittsburgh. Use of wrought-iron pipe for services aboard ships also is depicted. In opening chapters various types of marine corrosion are discussed and recommended procedures in fabricating and painting wrought iron are set forth. Copies are available to responsible interested persons on request.

**Newscast, a periodical** edited for those who design, specify, use or purchase stainless steel valves, fittings and engineered castings is devoted to the task of providing information about the uses and properties of stainless steel castings. The publication is available on request from Cooper Alloy Foundry Co., Bloy St. and Ramsey Ave., Hillside, N. J.

**Vitron Underground Glass Pipe Wrap** is to be used on the 1840-mile 30-inch gas pipe line from Texas to the New York line to be built by Trans-Continental Gas Pipe Line Corp., according to Gass Fibers, Inc., Waterville, Ohio. The 40 million square feet of fabric to be used on the job was sold by M. J. Crose Manufacturing Co., Tulsa, Okla., exclusive foreign and domestic distributor of the material. First shipments of the fiber will be to Alabama and Georgia depots where work began in April. The Trans-Continental line, estimated to cost \$191,000,000, will run from Mercedes, Texas, to 132nd Street and Hudson River, New York City. Potential of the line will be 5 million feet daily. Gas from Texas, Louisiana and Mississippi will be drawn on. Consumers in the Carolinas, Virginia, Maryland, Delaware, Eastern Pennsylvania, New Jersey and Metropolitan New York will use the fuel.

**Dow Chemical Company** displayed commercial applications of magnesium at the Magnesium Association Meeting and Product Exhibit, April 19-20, Edgewater Beach Hotel, Chicago. Representatives of the magnesium division of the firm scheduled to deliver papers are Dr. G. H. Found, manager of technical service and development who will discuss "Magnesium in Transportation," W. S. Loose, general sales manager, who will discuss "The Magnesium Industry" and H. K. DeLong, of the magnesium laboratory, who will talk on "Surface Treatment and Finishing of Magnesium."

"**How Magnesium Pays**" was the theme of the exhibit by Dow Chemical Co. at the Western Metal Congress and Exposition to be held April 11-15 at Los Angeles, Cal.

**National Carbon Company's** motion picture "Carbon Arc Projection" has been selected by the Office of International Information, Department of State for distribution throughout 52 foreign countries and their dependencies.

**A. B. Judd Supply Co.,** Houston, Texas has been appointed distributor for Tube-Turn welding fittings and flanges.

**Dowell, Inc.,** a wholly-owned Dow Chemical Company subsidiary has taken over sale of cathodic protection products for retarding electrolytic corrosion of pipe lines and industrial equipment. Guy Williams, assistant sales manager heads the new sales activity and Yale Titterton, a Dow corrosion and development engineer for seven years will handle technical service aspects.

**Ni-Resist, a cast nickel alloy,** will be discussed in all its aspects at a series of meetings to be conducted by the International Nickel Company to be held in Philadelphia, April 15; Cleveland, Ohio, April 22; Birmingham, Ala., May 19; San Francisco, Cal., September 16 and Los Angeles, Cal. September 23.

### NEW CORPORATE AND ASSOCIATE MEMBERS

Following is a list of new Corporate and Associate members who have joined NACE during the period from March 15 to April 15, 1949, bringing to 269 the number of these types of sustaining Association memberships:

Otis Elevator Co., New York, N. Y.	Joseph Mastroberte
N. A. Saigh Co., San Antonio, Texas	



## NEW PRODUCTS

### Materials—Service—Literature

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**Carpenter Stainless Steel No. 20** now is being used for precision parts, such as valve trim and many types of fastenings. This alloy, in its wrought form now is being commercially produced as bar stock, wire, strip, tubing, pipe, sheet and plate. Type analysis is: Carbon, .07 percent max.; manganese, .75; silicon, 1.00; chromium, 20.0; nickel, 29.0; molybdenum, 2.00 min.; copper, 3.00 min. Information about the characteristics of the alloy can be obtained from The Carpenter Steel Company, Reading, Pa., or Alloy Tube Division, The Carpenter Steel Company, Union, N. J.

**An Electric Heater**, the heating element of which consists of a nickel chromium resistor wire, insulated and sheathed in seamless metal tubing which is imbedded in a one-piece aluminum finned casting is being manufactured by the Electromode Corp., 45 Crouch Street, Rochester 3, N. Y., for use in hazardous locations where explosive or combustible substances are present. Three models, of 2000, 4000 and 6000 watt sizes are available.

**New Designs of Norcodal** heating devices have been added to the line manufactured by the Heil Process Equipment Corp., Cleveland, Ohio. Norcodal heat transfer equipment now includes a grid exchanger as well as tube immersion units, electric tank heaters, shell and tube exchangers and steam jets. These impervious graphite devices are constructed for service in very corrosive environments being resistant to attacks by most acids, alkalis, solvents and salts, but excepting strong oxidizers.

**Edison Electric Institute's** illustrated field manual "The Application and Care of Rubber Protective Equipment," developed especially for those concerned with the maintenance of electrical conductors is designed to portray in a comprehensive and concise manner the proper use of rubber protective equipment for work on electric lines.

### Personals

**Dr. Edgar Reynolds Smith**, chief of the physical chemistry section of the National Bureau of Standards has been awarded the 1948 Hillebrand prize of the Washington Section of the American Chemical Society. He was cited for his "original work in physical chemistry, more especially contributions to electrochemistry and ebulliometry."

**H. Neville Potter** has been named executive vice-president and general manager by Dearborn Chemical Company, Ltd., Toronto, Canada. **Arthur L. Johnson**, treasurer of Dearborn Chemical Company, Chicago, Ill., has been elected secretary-treasurer and a member of the firm's board of directors.

**Dr. Robert Simha**, consultant on fundamental polymer research at the National Bureau of Standards has been elected to honorary membership in the honorary scientific fraternity Sigma Xi.

**Mason Britton**, president Metal Cutting Tool Institute has been named director-at-large of the Advertising Council, Inc. at a meeting in New York.

**Harold F. Stose**, chemical engineer, has joined the engineering consulting firm of Sam Tour & Co., Inc., as head of the chemical engineering department. Mr. Stose has had twenty years' experience in chemical research, development and testing. He is an M.I.T. graduate and a member of numerous technical societies.

**Dr. Hans Kohler**, formerly a member of the research laboratories of the Signal Corps, has been appointed to the staff of the National Bureau of Standards where he will be concerned with theoretical work in the electronics division.

**Dr. Eugene L. Woroch** and **James E. Hennings** have joined the staff of Bjorksten Research Laboratories, Chicago. Dr. Woroch, who has been working in the field of sterol substances, is a section leader and Mr. Henning, previously with the Kester Solder Co., Chicago, is a research chemist.

**William S. Loose**, formerly director of the laboratory development section of the magnesium laboratory, Dow Chemical Company, has been appointed magnesium division sales manager.

**James E. Zeigler** has been added to the Cooper Alloy Foundry Co., Hillside, N. J., sales engineering force. His station will be Cleveland, Ohio. He is a Purdue graduate.

### Movies Are Shown At NACE Conference

Motion pictures shown during the conference were as follows:

"Nickel Mining," courtesy of International Nickel Co., New York.

"Corrosion," Allegheny Ludlum Steel Corp., Pittsburgh, Pa.

"Welded Line-Pipe Made the Smith-Way," A. O. Smith Corp., Milwaukee, Wis.

"Watts in Glass," Owens-Corning Fiberglas Corp., Toledo, Ohio.

"Birth of an Oil Field," Shell Pipe Line Corp., Houston, Texas.

Background organ music during the April 13 banquet of NACE was played by Hy Geis on an organ supplied by Mabley & Carew Company, Cincinnati.

**Model 901 Series** Weston ac and dc portable voltmeters, ammeters, milliammeters and microammeters have been announced by Weston Electrical Instrument Corp., 617 Frelinghuysen Ave., Newark 5, N. J.

## NACE REPRINT PRACTICE

Requests for prices on reprints of material appearing in **CORROSION** should be addressed to Norman Hamner, Managing Editor, National Association of Corrosion Engineers, 905 Southern Standard Bldg., Houston 2, Texas. Prices usually cannot be given until after articles have appeared in **CORROSION** although requests for prices may be submitted at any time. Type from which technical articles are printed is kept standing for 90 days after date of issue, and reprints ordered during that interval will be from standing type. For

reprints ordered after expiration of this period, write for details.

Permission to reprint articles usually is given to responsible firms and individuals who wish to have the work done themselves. NACE requires, however, that proper credit be given **CORROSION** at an appropriate place on all reprint material. The association also requests that reprint style closely conform to that approved by its board to be in keeping with the aims and objectives of the association and that copies of reprints made under this authority are supplied NACE for recording purposes.

# Manual for Publications Committee

## Introduction

This manual presents a resume of the functions of the Publications Committee together with its practices and general procedures. Certain matters of policy in regard to handling and securing of technical papers are also included.

The specific functions of the committee as set up in the By-Laws of the Association are outlined briefly. It is charged with the general control of publications which include 1) the programs for annual meetings, 2) CORROSION, 3) annual abstract publications, 4) bibliographies, and 5) miscellaneous publications. The further functions of the committee are to set up rules for preparation, presentation, and acceptance of papers and to appoint necessary subcommittees to carry out the above details.

## OPERATION OF COMMITTEE

### I. Control of Publications

Programs for Annual Meetings. The executive secretary circulates the convention program dummy to the publications committee chairman, to the executive committee, and to the general convention chairman for suggestions as to make-up. The galley proof is re-submitted to the publications committee chairman for final approval.

Magazine CORROSION, composed of five main sections, is produced through the combined efforts of the editor and managing editor. The editor reviews and approves all copy (exclusive of advertising), after it has been reviewed by the editorial review committee, assists the publications committee chairman in soliciting prospective authors for papers to be placed before the editorial review committee, and arranges for reprinting of outstanding articles. The managing editor has full responsibility for make-up and production, prepares copy for the news section, and arranges the printing schedule. The practices and procedures for handling the various sections are discussed below.

Technical papers are derived from four sources: 1) Annual meetings, 2) regional and sectional meetings, 3) articles submitted by organizations or authors either by invitation or voluntary contribution, and 4) reprints of outstanding articles published in other magazines or journals. All papers from whatever source are reviewed and accepted or rejected by the editorial review committee. Before a paper is rejected, the author or organization contributing it is contacted with suggestions, if possible, as to changes which would make the paper acceptable. The paper is reviewed again if the author can make proper changes and resubmit it.

Editorial section is made up of messages from the officers and selected committee chairmen. These are selected by the executive committee. Each editorial is approved by the executive committee and editor of CORROSION before publication.

News section, including equipment news, is the direct responsibility of the managing editor, and final copy is ap-

proved by the editor. Topic of the Month column is contributed by CORROSION correspondents.

Abstract section provides as complete a coverage as possible of all articles printed on the subject of corrosion. The procedure for securing these abstracts, contributed by organizations preparing abstracts for their own use, was set up through the cooperative effort of the former American Coordinating Committee on Corrosion and NACE. The abstract contributors are generally given credit by code. The chairman of publications committee supervises production of abstracts at present.

Advertising section is not a direct responsibility of the publications committee. The managing editor handles all make-up and arrangement of advertisements.

Annual Abstract Publication is a complete compilation of abstracts of articles on corrosion published in a single year. The majority of these abstracts will have been published in CORROSION as a part of the abstract section. However, there are some additions. The abstract subcommittee is responsible for this publication.

Bibliographies. At such time as it appears expedient to make prepared bibliographies available to workers in corrosion on a fee basis, the publication committee will make provision for their production.

Miscellaneous. The publication committee makes provisions for the issuing of such publications as reports of Technical Practices Committee, manuals, specifications, membership lists, brochures, etc., after receiving instructions from the board of directors.

### II. Rules for Preparation, Presentation, and Acceptance of Papers

A pamphlet entitled "Guide for Preparation and Presentation of Papers," containing a tentative set of rules was prepared by a rules subcommittee and is available from the Houston office. The rules subcommittee reviews and revises this pamphlet from time to time.

### III. Subcommittees

Rules Committee is discussed above. Abstract Committee is charged at present with selecting and setting up a mechanical filing system for handling abstracts. This subcommittee edits the annual abstract publication.

Editorial Review Committee revises and presents acceptable papers to the editor of CORROSION. This committee contacts authors to see that rules requirements are fulfilled and assist authors in improving their papers.

Miscellaneous Publication Committee reviews material to see that it conforms to accepted style and makes recommendations as to form in which it is to be issued.

CORROSION correspondents are responsible for the Topic of the Month column in CORROSION.

### IV. Policies

Certain policies in handling technical papers have been developed in line with the aims and objectives of the associa-

tion which should be expanded beyond the scope of duties. One of the primary aims is to provide a means of exchange of knowledge and ideas. The association stands on the premise that the rehashing of the same facts for producing numerous articles detracts and confuses the issue. Similarly the simultaneous publishing of the same article clutters up the abstracting literature. The elimination or reduction of this confusion is one of the aims of the association and the following policy is encouraged.

It is the policy of NACE and its publications committee to consider a paper presented at an annual meeting as property of the association for subsequent printing in CORROSION and available to other publications only as reprint material. In a similar manner, articles from other publications are reprinted as reprint articles. An author is not requested to submit a paper to NACE at the same time he has given it to another publication or association without giving explicit credit to original source. NACE emphasizes its willingness to cooperate with other publications by granting them permission to reprint articles from its publications with the regular credit line. Short abstracts of papers to be presented at annual meetings are available to the trade press through the Central Office. A similar policy may be adopted for the regions to operate in the following manner:

- 1) The regional program chairman is supplied with copies of the "Guide for Preparation and Presentation of Papers."
- 2) He requests the author of the paper presenting research or practical data, or an outstanding survey article to submit three copies of the paper for reprinting after their appearance in CORROSION if accepted by editorial review committee.
- 3) He advises outside publications that papers are the property of the association and will be available to them for reprinting if accepted by editorial review committee.
- 4) Such requests are transmitted along with the paper when it is sent to editorial review committee. If for any reason the paper is not to be printed in CORROSION, the author is advised of the release of his paper and of the interest expressed by the outside publication.

The local section program chairman should advise the regional chairman of outstanding papers presented at local section meetings so that they may be used in regional meetings. Local section papers may be submitted directly to CORROSION. The point must not be overlooked that both local sections and regions may derive great benefit from papers and discussions dealing with well-known and established facts and ideas. Therefore, they should not limit their papers to ones which would be acceptable for publication in CORROSION. However, they are encouraged to report original work and to transmit such papers to the national office.

All copies of papers, technical and otherwise, are forwarded to Houston office and are distributed from there.

Submitted by  
IVY M. PARKER, Chairman,  
Publications Committee of NACE.

# ASTM Reports Corrosion Activities

Considerable data of interest to the membership of the National Association of Corrosion Engineers was developed during the meeting of almost 300 committees of the American Society for Testing Materials in Chicago and elsewhere February 28-March 4. A summary of some committee reports follows:

**Committee E-12 on Appearance**—Organization meeting. Officers M. Rhea Paul, chairman, Frederic H. Rahr, Inc.; R. C. Adams, vice-chairman, U. S. Naval Engineering Experiment Station, Annapolis, Md.; Daniel Smith, secretary, Interchemical Society. Purpose of the work to be done by this committee is to formulate terms, develop measurement methods and serve in liaison with other organizations working toward the same objectives.

**Committee A-10 on Iron-Chromium-Nickel** and related alloys. A-10 data on cast and wrought alloys will be ready for publication soon. The corrosion testing subcommittee has completed its program of atmospheric exposure testing and is assembling test specimens to be set out at a number of sites. Plans are complete for the symposium on "Relations of Performance of Stainless Steel in Evaluation Tests to Performance in Service." The fourth round-robin tension testing series has been completed. The subcommittee on specifications for flat products considered the request of the boiler code committee to add some new grades of corrosion-resistant steel to some of its specifications.

**The Subcommittee on Specifications for Castings** effected final reconciliations between specifications for corrosion-resistant iron-chromium and iron-chromium-nickel alloy castings for general application, heat resistant and alloy composition limits published by the Alloy Castings Institute.

**Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys.** A number of current test programs were reviewed and the status of certain testing methods were considered. The Subcommittee on spray testing recommended minor changes to improve control of testing conditions and make the method applicable to painted panels. The subcommittee is making studies of the acetic acid-salt spray test for plated die castings. The subcommittee on weather reported Mr. O. B. Ellis (in charge of its program which involves exposure of test samples in areas to study relative corrosiveness of various atmospheres) will prepare a paper on factors in measuring the corrosiveness of atmosphere which is to be appended to the subcommittee's annual report. The subcommittee on galvanic and electrolytic corrosion reported disk samples with aluminum and magnesium couples will be exposed at several locations this summer.

**Committee B-8 on Electrodeposited Metallic Coatings** is amending and retaining as tentative specifications for electrodeposited platings of zinc, chrome finishes on electrodeposited zinc, hot-dip galvanized and zinc die-cast sur-

faces. H. A. Pray of Patelle Memorial Institute presented a report on "Atmospheric Exposure of Electroplated Coatings on Steel" which will be appended to the annual report.

**Committee B-9 on Industrial Waters** reviewed further and made substantial progress on the manual for industrial water, now in preparation. The subcommittee on methods of sampling recommended a tentative method of steam sampling, advanced to standard the method for sampling water for industrial uses and the recommended practice for field sampling of water-formed deposits. The subcommittee on methods analysis proposed adoption as standard the methods of determination of chloride ion and sulfate ion. The method of determination of dissolved solids was presented as tentative along with two new methods, one for acidity and alkalinity and the other for iron in industrial water. The method of test for dissolved oxygen is retained as tentative and a new non-reference method for determining total carbon dioxide is being added to the present method (D 513) and the subcommittee is working on new methods for specific electrical conductance and hardness of water.

The subcommittee on methods of testing is recommending for advancement to standard the methods for test of embrittlement (D 807) and the NDHA Corrosion Test (D 935).

**Committee A-5 on Corrosion of Iron and Steel.** Subcommittee on methods of testing recommended revision in definition of end point for Preece Test, recognizing both exposure of basis metal and deposit of copper as the end point. Specifications changes on galvanized zinc-coated iron or steel sheets and long term steel sheets to include sheets coated in coils was studied. The subcommittee on hardware specifications recommended the specification on hot-dip zinc-coated iron and steel hardware be advanced to standard after the "embrittlement clause" was made to agree with the standard on hot-galvanized zinc coated structural steel shapes. Corrosion inspections will be made on an annual basis in the future instead of semi-annually as heretofore by the subcommittees on sheet and wire testing. The Brunot Island site must be abandoned soon and it was decided to remove all specimens from the site after the 1951 inspection, relocating only wire specimens of a special nature.

## Aging of Rubber Symposium is Given

A symposium on the aging of rubber and other elastomers comprising six papers was presented at the technical session of the 1949 ASTM spring meeting in Chicago March 2. About 400 attended.

The symposium was developed under auspices of Committee D-11 on Rubber and Rubber-like Materials. The com-

mittee responsible was headed by G. C. Maasen, R. T. Vanderbilt & Co., Inc. assisted by committee officers Simon Collier, chairman, Johns-Manville Corp. and Arthur W. Carpenter, secretary, B. F. Goodrich Co.

The following papers were presented: "Mode of Attack of Oxygen on Rubbers," by A. M. Neal, assistant director, Rubber Laboratory, E. I. DuPont de Nemours & Co.

"Oxygen Absorption Methods and Their Utility and Limitations in the Study of Aging," by J. R. Shelton, Case Institute of Technology.

"Chemical Changes in Elastomers and Antioxidants During Aging," by John O. Cole. Research Laboratory, Goodyear Tire and Rubber Co.

"The Physical Aspects of the Aging of Rubbers," by M. C. Throdahl, Rubber Laboratory, Monsanto Chemical Co.

"Aging Effect of Ozone and Light on Rubbers," by J. T. Blake, Simplex Wire and Cable Co.

"Effect of Temperature on the Aging of Rubbers," by M. J. Schoch, Jr., Hewitt-Robins, Inc. and A. E. Juve, Research Center, B. F. Goodrich Co.

## BOOK REVIEWS

**CHEMICAL AND ELECTROPLATED FINISHES.** By H. Silman. The Sherwood Press, P. O. Box 566, Pacoima, Cal. 6 x 9 inches, 414 pages, cloth. Price, plus postage \$10.

The book pertains to finishes applied to metals for decorative or protective purposes from aqueous solutions with or without electric current. It is especially concerned with the technical aspects of metal finishing from process and plant points of view. There is a chapter on the corrosion of metals.

**BIBLIOGRAPHY ON X-RAY STRESS ANALYSIS — WITH SUBJECT INDEX.** By Herbert R. Isenburger. St. John X-Ray Laboratory, Caliform, N. J. Lithographed, 8½ x 11, 17 pages. \$3.00.

A brief discussion is presented of theory of X-ray diffraction measurements of crystal deformation resulting from an application of stress. There are listed chronologically 240 references from 1925 to 1948. Accompanying subject index facilitates use. Publication is designed to be of interest to scientist or engineer who desires a ready source of information on this experimental technique.

## MEETINGS

Instrument Society of America, May 12-13, 1949, Royal York Hotel, Toronto, Canada.

American Electroplaters Society, Milwaukee, Wis., June 27-30.

Fourth National Instrument Exhibit will be held at St. Louis Municipal Auditorium, September 12-16, 1949.





# Corrosion Problems

**No. 23—(A)** In applying cathodic protection to lead cable sheaths, what is considered the minimum negative potential that the lead cable sheaths must maintain to earth, measured with a lead electrode or copper sulfate, in order to protect the lead cable sheaths from corrosion when installed in either conduit or direct burial in the earth?

**(B)** What is the maximum negative potential that may be maintained before cathodic corrosion will take place on the lead cable sheaths?

Questions and Answers for this section should be submitted to L. G. Vande Bogart, Crane Co., Engineering and Research Division, 836 S. Michigan Ave., Chicago, Illinois. All questions will become property of NACE. Those not printed will be answered by mail. Questions should carry sufficient detail to describe the problem. Answers to printed questions are solicited. Authors of questions will remain anonymous to readers, while authors of answers may remain anonymous by request.

would be less uniform than a galvanized coating. Suggest painting of tubing to increase cathode resistance and polarization of bare spots.—J. M. Pearson.

**No. 24—**Occasionally severe corrosion of insulated underground piping occurs as a result of infiltration of water (liquid or vapor) into the mass of insulating material. Is the physical or chemical character of the insulating material a controlling factor in such corrosion, or is this merely a form of "contact corrosion" which is equally severe with all insulating materials? To what extent does this corrosion depend on soil characteristics and/or the composition of the soil water which enters the insulating layer? Are there any published reports dealing with this problem?

**Editor's Note:** The above question is a condensation of a letter which was received from one of our friends across the sea. It originally was directed to the Houston office of NACE prior to the initiation of "Corrosion Problems," and considerable time has elapsed since it was first received. If any of our readers can be of any assistance to this contributor, a prompt response will be appreciated.

**No. 25—**What is the comparative corrosion behavior of the common forms of ferrous pipe when used for coils in spray coolers?

**Editor's Note:** Answers to this question should take into consideration both seamless and welded pipe, black and galvanized.

**No. 26—**Is there any field experience with any environments which indicates that crevice corrosion of flange faces can be reduced or eliminated by varying bolt stresses without changing gasket material or design?

**Editor's Note:** Assume in all cases that the bolts are stressed sufficiently to prevent joint leakage.

## ANSWERS

**No. 7 (January, 1949)—**Galvanic anodes on the outside of tubing would last about as well as galvanizing. The protection is temporary. Galvanic anodes in the annulus would need to be uniformly distributed to get coverage and

It would seem possible to provide at least some cathodic protection for the casing by installing anodes on the outside of the tubing. Owing to the proximity of tubing and casing, it might be necessary to have the anodes close together on the tubing so that the intensity of the current imposed on the casing surface would everywhere be adequate to oppose the current tending to flow from casing to tubing through the mud filling. Insulating rings placed about the tubing to prevent metal to metal contact with the casing might be more effective for preventing the flow of galvanic current. Filling the annular space with a high pH, salt-free mud containing an inhibitor would seem to be a more practical means of preventing corrosion.

Anodic material dispersed in the mud would not likely protect the casing unless it reacted chemically with ingredients of the mud to increase the pH of the mud or otherwise condition it so that it would not serve as a medium for corrosive action.—C. K. Eilerts.

**No. 8 (January, 1949)—**In an environment involving  $H_2SO_4$  or  $HCl$  at  $200^\circ F$ , pH 1.0-3.0, Type 316 is far superior to Type 304 stainless, but neither is sufficiently resistant to be considered economical when compared with many other materials readily available. The oxidizing capacity should be checked very carefully to determine if a chrome-nickel, or a nickel-chrome alloy will retain a partially passive state or will be in the active state. If no oxidizing capacity exists, the question of galvanic action would have to be considered.—W. E. Pratt.

Reference to Type 304 and Type 316 as casting designations is not appropriate and it should be pointed out that the general designations 18-8-S and 18-8-S-Mo or the specific Alloy Casting Institute designations CF-8 and CF-8M, respectively, are much more correct. Since the chemical composition range for these castings as given by ASTM designation A 296-46 T and the Alloy Casting Institute are in agreement for the principal elements, it would be desirable to publish these recommended chemical requirements and point out that they do differ from the chemical composition range for Types 304 and 316. This would help clarify the thinking of many individuals who use these wrought designations indiscriminately.

In most instances it would be much better to make other, more suitable alloy selections for the severe corrosive environments outlined, since it is usually risky to depend on the continual presence of inhibitors or passivators. However, when the 18-8-S and/or 18-8-S-Mo alloys

are suitable, the molybdenum bearing alloy is usually the more resistant to dilute sulfuric and hydrochloric acids. In the services where either alloy is suitable it has been determined that there is no substantial difference in the corrosion resisting properties of the wholly austenitic or the partially ferritic castings of these alloys.—W. A. Luce.

**No. 11 (February, 1949)—**Cast iron is comparatively cheap, so that corrosion damage is usually repaired by replacing the damaged part. There are exceptions, of course, such as seats and discs in control valves and similar devices in which the damaged area can be removed and replaced with mechanically fitted-in parts made of corrosion resisting materials. Occasionally such replacements are attempted by the welding procedure, but the occurrence is rare because the risk of loss is great and the cost in time and material is large in comparison with the value of the part.

The repair of corroded cylinders by relining with cylinder liners in engines, compressors and piston pumps represent another practice that is employed to repair a corroded cylindrical mechanism. In these cases, the corroded surfaces are machined away and corrosion resistant sleeves inserted. The practice is common in the chemical and petroleum industries.

Occasionally large vessels may be sprayed with a corrosion resisting metal to extend the life of the equipment. Pots handling corrosive liquids or molten metals have been processed through a procedure of coating them with .015" of stainless steel and finishing the surface with aluminum. The procedure is somewhat similar to the lining of pipe with bitumastic enamels or portland cement, both of which may be applied in the field if the volume involved is sufficient to warrant transportation of equipment.

There is also the common practice of dip coating or tinning castings such as dairy equipment or meat chopper parts. These are usually unimportant enough to allow them to be processed through a repair shop which takes time to clean and coat them in the course of their rehabilitation.

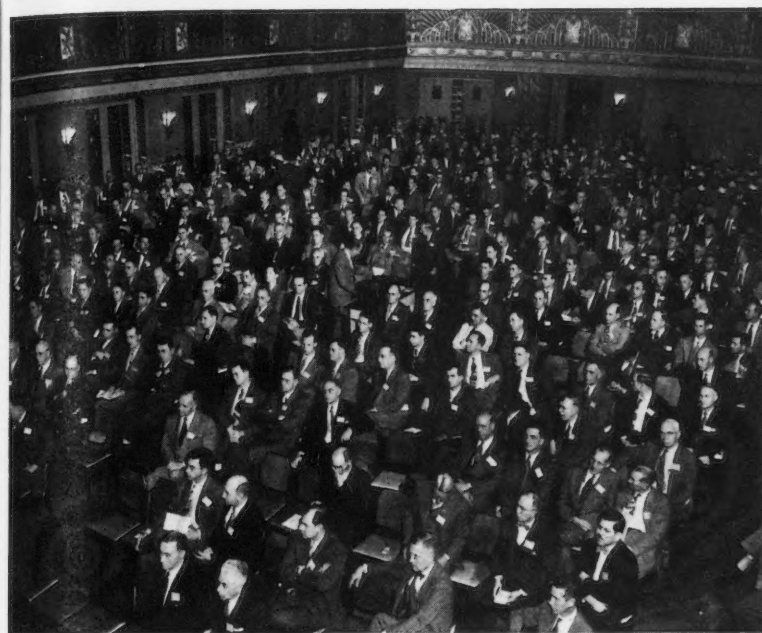
Some of these practices are fully described in a book to be published under the authorship of Mr. Albert Dietz of the Massachusetts Institute of Technology, entitled "Engineering Laminates" and published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York, N. Y.—J. S. Vanick.

## Do You Have A CORROSION PROBLEM?

If you do you are invited to submit it to the editor of this section for an answer by persons who have met a problem similar to yours and have found solutions.

## REPORT ON THE FIFTH ANNUAL CONFERENCE

## Cincinnati Meeting Is Successful



The view above is the Netherland Plaza Hall of Mirrors during presentation by Dr. H. H. Uhlig of his paper, "Why Metals Corrode."

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Considerable interest was manifested by conference guests in the Pittsburgh Symposium book. Numerous orders for the book were taken at the NACE booth.

The Bureau of Standards booth attracted a great deal of interest during the conference with its displays of test material showing various kinds of corrosion.

The 1949 Official Conference Program was felt by many to be the best-arranged and most easily readable one in their experience.

## Annual Awards Are Presented April 13

Incoming NACE President Dr. R. B. Mears was given the Whitney Award for achievement in corrosion science, and the Speller Award for achievement in the field of corrosion engineering was given to outgoing President Frank LaQue at the 1949 banquet held Wednesday night, April 13 in Hotel Netherland Plaza's Pavillon Caprice room.

Outgoing President LaQue also received a certificate of appreciation for his work as head of the association during the year as did Past President G. R. Olson, F. S. McElhatton and R. A. Brannon.

New directors Ellis Verink, Jr., and D. C. Glass were introduced by President LaQue.

Dr. William F. Clapp, noted marine biologist gave a witty and appreciated address.

## Correspondent Named

E. R. Begole of Socony-Vacuum Oil Co., 917 First National Bank Building, Wichita, Kansas, now is Corrosion magazine's correspondent for Petroleum Production and Transportation succeeding Bruce L. Corey.

Records for attendance, sustained interest and general excellence of arrangements and material were broken at the Fifth Annual Conference of the National Association of Corrosion Engineers in Cincinnati April 11-14, it was indicated from expressions by members, visitors and exhibitors. Ladies present were given an enjoyable and interesting program.

Exhibitors expressed satisfaction with the quality and frequency of inquiries they received and several already have indicated their intention to participate in next year's conference.

Proceedings of the conference got underway with a minimum of friction and delay, indicative of the effective preliminary planning by members of the various conference committees, both national and local.

The opening general business meeting was devoted largely to annual reports by retiring President F. K. LaQue, Treasurer O. C. Mudd and Executive Secretary A. B. Campbell and receipt by the secretary of recommended changes to the association's constitution and by-laws which will be presented to membership for vote by letter ballot. Changes developed by the Policy and Planning Committee under Dr. H. M. Trueblood, and previously approved by the association's board for presentation to a general meeting, were explained point by point. Eight major committee reports also were given.

The same atmosphere of interest and enthusiasm was evident throughout the four days of the conference and many who were unable to remain for the whole program expressed regret at the necessity for their early departure.

Attendance at committee meetings was heavier than anticipated in many cases, and members met for extra sessions after it proved impossible to cover the agenda in time allotted.

Technical committee chairmen in particular were encouraged by the increased interest evidenced in the work and plans of their organizations, and in most cases, substantial progress either in achieving previously established goals or in setting programs of investigation was reported.

Widespread satisfaction with the subject matter, variety and value of technical papers was expressed frequently. Inquiries about dates of publication in CORROSION of some papers were received even before the papers themselves had been delivered. Members and visitors alike showed interest in the association's publications, especially in the recently published Pittsburgh Symposium on Cathodic Protection and the forthcoming report of the Condensate Well Corrosion Committee.

Numerous applications for membership were received during the conference by the NACE staff and many others are expected to develop as a consequence of the conference.

# NACE Financial Progress Is Detailed

MEMBERSHIP	1946	1947	Percent Increase	1948	Percent Increase
Active.....	758	1,059	39.6	1,473	39.1
Junior.....	2	9	350.0	19	111.0
Corporate.....	32	109	240.0	185	69.6
Associate.....	9	33	266.6	60	82.0
Total.....	801	1,210	50.7	1,737	43.5
<b>Membership Activity:</b>					
Revenue.....	\$ 7,818	\$18,864	141.0	\$25,678	36.0
Expense.....	13,590	16,173	19.0	22,192	18.1
Gain (Loss).....	(5,772)	2,691	320.1	3,486	51.5
Expense Includes:					
Salaries.....	7,464	8,846	18.5	14,540	64.3
Equipment.....	384	641	67.0	1,314	105.0
<b>"Corrosion" Magazine:</b>					
Revenue.....	19,368	33,918	95.2	49,278	45.3
Expense.....	23,081	36,883	60.0	45,712	23.9
Gain (Loss).....	(3,713)	(2,965)	25.3	3,566	210.0
Expense Includes:					
Salaries.....	6,948	10,245	47.1	11,301	10.3
Equipment.....		800		3,838	380.0
<b>Conference and Exhibit:</b>					
Revenue.....	10,890	12,038	10.5	19,240	59.7
Expense.....	6,301	7,048	11.8	10,159	43.2
Gain.....	4,589	4,990	8.7	9,081	81.9
Combined Revenue.....	38,076	64,820	70.3	94,196	45.3
Combined Expense.....	42,972	60,104	40.0	78,063	29.7
Gain (Loss).....	(4,906)	4,716	114.4	16,133	243.0
Previous Year Worth.....	7,094	2,188		6,904	
Net Worth.....	2,188	6,904	215.8	23,037	233.5
<b>Total Expense:</b>					
Number Active Members.....	56.62	56.75		53.00	
<b>Total Expense:</b>					
Total Membership.....	53.64	49.66		44.93	

## Several Changes of Directors Are Effected at Conference

Several changes in the board of directors were effected during the conference.

Vance N. Jenkins resigned his directorship to become vice-president.

Appointed to take his place as a representative of corporate membership was W. R. Myers of E. I. duPont de Nemours & Co., Inc., Wilmington, Del., who will fill his unexpired term through 1951.

Maynard H. Jackson, of Standard Pipeprotection, Inc., St. Louis, Mo., was appointed to take the place vacated by Dr. Mars G. Fontana as representative of the active membership. His term expires in 1950.

Irwin C. Dietze of the Dept. of Water and Power, Los Angeles, Cal., took his place as representative of the Western Region.

E. P. Noppel, Ebasco Service, N. Y., vacated the North East Region directorship to become chairman of the policy and planning committee.

Dr. Mars G. Fontana of Ohio State University, Columbus, Ohio, was named chairman of the Technical Practices Committee, succeeding Dr. R. B. Mears, resigned to become president.

L. A. Baldwin, Johns-Manville Sales Corp., New York, N. Y., was appointed chairman of the regional management committee.

This completes the roster of the board

except that the resignation of Mr. Noppel as director for the North East Region leaves this post vacant until the region can act to replace him.

Terms of office of national officers and board members begin as of the day following the last day of the annual conference.

## Registration Reaches 911 at Conference

Preliminary tabulations indicate registration during the Cincinnati conference was 911. This is 161 more than were registered at the 1948 conference, Central Office records indicate.

In addition to the known paid registration there were a number of visitors, mostly from the Cincinnati vicinity, who attended technical sessions but did not formally register.

A notable characteristic of the association was emphasized by the wide geographic distribution of conference registrations, indicative of the drawing power of the program arranged.

Nils H. Nyquist, representing the Norwegian Industries Commission, which has headquarters in New York, was an interested visitor at the 1949 Conference. He asked for abstracts of all technical papers to be sent back to Norway.

## Treasurer O. C. Mudd Gives Yearly Report

Reports by your treasurer for previous years have been made with some apologies because of the association's small financial gain and accumulated surplus. This year's financial condition shows much improvement.

The tabulated data illustrates membership revenue and expense changes and trends through the years of 1946-7-8.

It is to be noted that the increase in company memberships has contributed much to our financial improvement.

"Corrosion" completed the past year showing a gain for the first time.

The high percentage increase under equipment expense is due to the purchase of reproduction equipment. However, these items appear as assets in net worth. This equipment will bring a return to the organization by reducing outside printing requirements and allowing publication of reports at lower costs.

The percentage gain in net worth reflects good administration and this is further substantiated by the continued decrease in cost per member. Attention is invited to this latter item which shows a benefit to active members of several times the amount of annual dues.

Cash surplus now makes it desirable to invest a portion. Mr. G. R. Olson suggested that investigation be made of possible short term loans. United States Treasury notes appear to be most satisfactory. These can be obtained for one month or longer yielding around 2 percent per year according to market conditions and length of loan time. Board approval will be necessary before such investments can be made.

Since the association is accumulating a reserve, it is urged that the board of directors give careful deliberation to allocating amounts for research or other projects furthering the association's aims that we may demonstrate our real worth to our members and to industry as a whole.

(Signed)

O. C. MUDD, Treasurer.

3-16-49

## NACE Lapel Pins Now Being Sold

Gold lapel pins in the shape of the NACE shield, with inlays of enamel and a center ruby are being offered for sale after their design had been approved by the board of directors at a meeting Sunday, May 10. D. E. Stearns, chairman of a committee designated to have a suitable design prepared for presentation, appeared before the board with samples of the pins.

Several orders for pins were received during the conference and additional orders may be placed by mail at Central NACE office. Price is \$7.00 and delivery is expected in about 30 days.



# Steady Growth Reported by LaQue



## Corrosion Will Have More Reading Matter

Decisions by the publication committee which met first at 9 a.m. Monday, April 11, and adjourned to meet again at 6 p.m. Tuesday, April 12, were as follows:

1. A recommendation that the budget for printing Corrosion magazine be increased \$500 monthly beginning with June, in order to permit a better balance between space devoted to editorial material and space devoted to advertising and pay for increased number of copies needed for subscribers. Board action on this request is to be sought.

2. Effective with the June issue an effort be made to keep the percentage of advertising space at about one-third of total space.

3. That whenever necessary 96 pages be published so available technical material can be used.

Discussion among members of the committee indicated an increase in quantity and quality of technical material is to be expected and that earlier publication of conference program papers is being arranged for.

Other changes in editorial policy included:

1. Dates of receipt by NACE of articles submitted voluntarily for publication will be published.

2. In the Corrosion Problems section questions will be repeated with every answer.

3. Authors will be given an opportunity to order at a reduced price in advance of publication, quantities of Corrosion magazine in which their articles are to appear. This will make it possible for authors to secure economically small quantities of their articles in print for private distribution.

4. A report of the rules committee now revising rules relating to handling of technical papers by NACE is expected in the near future for review by members of the committee.

5. A short-form digest of mechanical

Members of the publication committee present at the annual conference in Cincinnati were, left to right, top row: Dr. A. W. Ryznar, A. W. Tracy, Dr. F. N. Alquist, Dr. W. Beck; lower row: Dr. Paul H. Bachman, Dr. Ivy Parker, Norman Hamner and George Diehlman. (Dr. Beck is a spectator.)

arrangement of papers, requirements of NACE with respect to numbers of copies of conference program papers, their distribution, manner of review and a chronological index setting forth deadlines will be prepared for comment by members of the publications committee and symposia chairmen of the 1949 conference.

6. Another sub-committee to handle the review and publication of technical committee reports will be needed soon, it was agreed.

## Quicker Processing of Papers Is Planned

More efficient handling of technical papers to facilitate and speed assignment to reviewers is expected from procedural changes to be put into effect at once among members of the Editorial Review Committee, action by the committee at a meeting 1 p.m. Monday during the annual conference indicated. Dr. Paul W. Bachman, chairman, outlined the work of the committee since its formation in November 1948, suggested various methods of procedure intended to speed the work of the committee.

Decisions reached included the following:

1. Five copies of abstracts of technical papers supplied Dr. Bachman from which his decision as to a reviewer is derived will be forwarded in order that all members of the committee may be advised of the content of papers assigned.

Copies of these abstracts will be forwarded in turn by Dr. Bachman with copies of the letter in which the assignment of a paper is indicated to all members of the committee. It thus will

### Introduction

At this time each year, the President is expected to present a brief account of his stewardship and a description of the state of the National Association of Corrosion Engineers.

It is, therefore, gratifying to be able to report that the state of the association is very good in practically all respects. Details will be provided by the reports of the secretary, the treasurer and of the chairmen of the standing committees. The present discussion will be confined to the highlights.

The association is maintaining a condition of steady growth with respect to the number of its members, its technical activities, its publications and other services to its members and to the engineering profession at large and to its status amongst the technical societies of the world.

As of March 28, membership of the association consisted of:

1660 Active Members

268 Associate and Corporate Members

20 Junior Members

Since the time of the 1948 conference the:

Active Membership has increased by

440 members or 36%

Corporate Membership has increased by

76 members or 65%

Associate Membership has increased by

28 members or 78%

These increases in membership have been featured by a considerable broadening of the base by way of extensions into many different fields where corro-

(Continued on Page 10)

be possible for reviewers who know of persons qualified to review papers to give the names of these persons to each other, thereby eliminating a difficulty experienced in which the reviewer found himself at loss as to whom a paper should be sent.

2. Members of the committee are to be kept better informed of the status of papers in process by:

- a. A more thorough transmission of copies of pertinent correspondence among members of the committee.

- b. Submission of a monthly status report by the managing editor of CORROSION to the editor and members of the committee.

The outlook for technical material of higher quality and greater variety is promising, it was the consensus.

Present at the meeting were the following members, besides Dr. Bachman: Dr. Ivy Parker, editor of CORROSION; George Diehlman, A. W. Tracy, Dr. F. N. Alquist, Dr. R. W. Ryznar, and N. E. Hamner, managing editor of CORROSION. Present as an observer was Dr. W. Beck.

## Steady Growth

(Continued from Page 9)

sion is encountered. This is especially desirable since it provides new channels of intercommunication; taps additional sources of experience and brings new thoughts to bear on common problems from different points of view. It has also been helpful from the commercial standpoint in increasing the attractiveness of our magazine "Corrosion" to the companies who support its publication by their advertising revenue.

Mr. H. H. Anderson, vice-president of the association, will report in somewhat more detail on the activities of his membership committee and its plans for the future. Even those members who have not had the privilege of seeing Mr. Anderson in action will appreciate from the concrete results of his tremendous efforts what a major contribution he has made, not only to the current success of the NACE but also to the establishment of the wide and firm support of management interests upon which the continued growth and usefulness of the association will depend. The natural desire of the directors to have Mr. Anderson succeed to the presidency could not be realized because of Mr. Anderson's declaration that other obligations would not permit him to accept nomination for the office. Undoubtedly, the new officers will wish to retain the advantage of Mr. Anderson's great energy and ability by getting him to continue to serve as Chairman of the membership committee.

### Technical Activities

The technical committees of the Association have been active in varying degrees, depending largely on the status of their organization. Some of the older committees like the Condensate Well Corrosion Committee have, under the chairmanship of Walter Rogers, already made substantial contributions to the solution of special corrosion problems. Others, like the committees on anodes for cathode protection have considerable work under way on which progress reports are being prepared currently, while others are perfecting their organization so as to insure sound and effective action on the topics with which they are concerned. There are now 13 sub-committees of the Technical Practices Committee under the chairmanship of R. B. Mears. The work of these committees as reported in our publications, is the obvious justification for our existence. It is, therefore, essential that the technical committees should function as quickly and as effectively as possible. This will require the wholehearted support of all the members who can best live up to their designation as "active" members of the NACE by volunteering for work on appropriate committees, by accepting invitations to serve in working groups and by attending diligently and promptly to any tasks that may be assigned to them.

### Corrosion Magazine

The year has been an especially good one for the publications committee. The progress of the committee is clearly evident to anyone who reads our publications and especially Corrosion Magazine. It has improved in appearance, in

the arrangement of its material and the addition of new features, in the quality of its editorial matter—helped considerably by the work of the newly established editorial review committee under Dr. Paul Bachman—and in the quality and quantity of supplementary information provided by our advertisers. Due largely to the latter feature, it is gratifying to report that during the calendar year 1948 and stemming largely from the efforts of G. R. Olson during his term as president, the magazine's revenue increased by about 49%. At the same time, in spite of considerably increased costs, the expense of publishing the magazine increased by only about 25%. The desirable result was that whereas in 1947 the cost of publication exceeded income by about \$3,000, in 1948 this was turned around so that income exceeded expenditures by about \$3,500.

### Advertising Revenue

There has been rather general agreement that the new larger size of the magazine represents an improvement in appearance. It also represents an increase in cost of the publication. While the increased cost can be justified by the result, it will require additional advertising revenue if the favorable balance shown by 1948 operations is to be maintained. The quality of the publication and the results of advertising in it will attract new advertisers and hold old ones. But the further help of all members is required. This can take the form of recommending the magazine to prospective advertisers, giving the names of potential advertisers to the executive secretary or the chairman of the advertising committee for appropriate follow-up and by patronizing the firms who support our publication with appropriate references to their advertising in Corrosion as the stimulus to inquiries.

Experience with the sale of advertising space during the past five years has demonstrated how difficult it is for an advertising committee to convert its enthusiasm and activities into the actual sale of advertising space. During 1948, Tom Holcombe and his advertising committee with the help of the headquarters staff, prepared and issued an attractive advertising sales brochure which has been distributed to hundreds of prospective advertisers. This has been followed up by direct correspondence, telephone calls and personal visits to prospects. The results of these efforts have been reasonably satisfactory but it appears that, in the future, we should provide for more first hand contacts between the headquarters staff and advertisers and depend mainly on this sort of activity to secure the necessary advertising revenue. This would mean that the principal function of the advertising committee would be to provide names of prospects, accompany staff members on calls in their territory and follow up details in individual cases as required.

### Other Publications

In addition to the 12 issues of Corrosion, the association has published the 1945 Corrosion Abstracts, the first in a series of annual publications of this sort and has practically completed the copy for the 1946 abstracts which will be published with our own facilities acquired during 1948.

In cooperation with the Electrochemical Society, the NACE also has just

brought out a bound volume comprising the many excellent papers presented in the Cathodic Protection Symposium held in Pittsburgh in December 1947.

As has been the case from the start, the success of the publications committee has been due largely to the invaluable work and plenty of it—of Dr. Ivy M. Parker, chairman of the publications committee. Dr. Parker's activities have been supplemented in a fine way by Barry Campbell and his staff at headquarters who look after the mechanical details of publication. The excellence of their combined efforts need not be stressed to the members of the NACE but it must be very gratifying to all concerned to be able to report that Mr. W. M. Wernett, just before he retired as managing editor of Corrosion, received the Award of Excellence from The Southwestern Association of Industrial Editors for improvement in appearance of Corrosion magazine during the year.

That the magazine may well be in line for new honors of this sort is indicated by the following quotation from a recent letter received by the new managing editor, Mr. Norman E. Hamner:

"Just a line to congratulate you on your January number of Corrosion. This is one of the finest issues I have ever seen of a technical magazine."

Incidentally this was followed by a contract for 12 months of advertising.

### Inter-Society Relations

During the year, the former NACE committee on Relations with Other Technical Societies went out of existence. This coincided with the dissolution of the American Co-ordinating Committee on Corrosion and the transfer of its records, activities and funds to the NACE. These two committees have been succeeded by a new NACE committee known as the Inter-Society Corrosion Committee. Up to now, 27 of the principal technical societies of this country, and Canada, plus a few governmental agencies, have appointed official delegates to the committee. Its status as a committee of the NACE indicates general recognition of the leadership of the NACE in this field.

### Amendments to Articles of Organization

At the last annual meeting, there was an expression of feeling that the method of nominating and electing officers of the association might be improved so as to give the members a more direct share in the processes. The board of directors agreed with this point of view and turned over to Dr. H. M. Trueblood and his policy and planning committee the problem of achieving the desired result. That Dr. Trueblood and his associates have been extremely diligent in their work on this problem is demonstrated by the detailed proposals for changes in the articles of organization that have been presented for your consideration and recommended action. It will be noted that in order to take advantage of the opportunity, Dr. Trueblood's committee and the board of directors have included a few other changes in the articles of organization that are considered to be desirable at this time.

Since Dr. Trueblood has spent hundreds of hours in studying the problem and combining to best advantage the suggestions received from several

(Continued on Page 12)



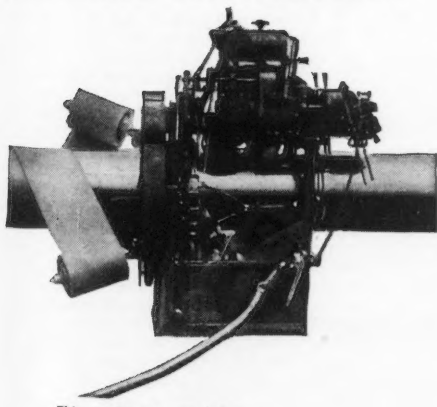
# PROTECTION SERVICE

Covers Every Pipe-coating Need

Materials and Application Procedure for:

- 1 Water Industries
- 2 Natural Gas, Crude Oils and Products Transmission
- 3 Professional Application in Plants and Yards
- 4 Distribution Systems
- 5 Reconditioning Operations
- 6 Gathering Systems
- 7 Recycling Operations

## Materials and Application Procedure for NATURAL GAS, CRUDE OILS AND PRODUCTS TRANSMISSION



This machine is applying Barrett Pipeline Enamel and wrapping asbestos felt.

Because of the variable weather conditions under which enamel is applied to pipe, it is necessary to have a *weatherized primer*.

Most primers are designed to dry under normal conditions (50% humidity at 70°F) during 9 months of the year, but Barrett also makes special primers for use in very cold and very hot application weather.

These primers form lasting bonds with all Barrett\* Enamels. Thus the line engineer is offered a wide range of primer-enamel combinations to suit his particular construction conditions.

The application of hot enamel over the primer *re-softens* the primer, and causes it to fuse with both the metal and the enamel for a perfect bond.

The initial and sustained dielectric values of Barrett enamels remain unchanged under all normal line currents. Since these values do not break down under electric currents put on the pipe, the economy of cathodic protection is assured.

The Barrett organization will be glad to confer with you on any of your pipe coating problems.

**THE BARRETT DIVISION**  
ALLIED CHEMICAL & DYE CORPORATION  
40 Rector Street, New York 6, N. Y.

\*Reg. U. S. Pat. Off.





## Steady Growth

(Continued from Page 10)

sources, I am asking him to carry the matter to what we hope will be its final stage by presiding at the open discussion of the proposed changes in the articles of organization which will form part of this meeting.

Before leaving this discussion of the regulations of the association, I should like to draw attention to the rule that puts a limit on the terms of directors. In principle, this is a wise rule that is likely to be approved by everyone. But in practice one could question the regulation that is responsible for our loss of Les Baldwin as a director because his term expires during this meeting. Les

has been a proverbial tower of strength on the board and in the executive committee. Since he has his headquarters not far from mine in New York, I have leaned very heavily on him during my term of office. I recommend to my successors that they continue to seek his advice when he is no longer a director, and to the members at large that they elect him to an appropriate office when the opportunity occurs.

### Regional and Sectional Activities

There has been a considerable and highly desirable increase in regional and sectional activities represented by the organization of new local sections in Philadelphia, Metropolitan New York, Pittsburgh and the Permian Basin—

formerly referred to as the West Texas section. Another new section has just been formed in the South Central Region at Beaumont, Texas.

There also have been some excellent regional meetings typified by the extremely successful one held by the South Central Region in Tulsa in September.

The organization of regions has from the beginning been stimulated and guided by Mr. George B. McComb as chairman of the regional management committee. Unfortunately, unusual demands on Mr. McComb's time made it necessary for him to resign late in the year. Our former president, F. J. McElhatton, has taken over this job and is carrying on in his usual capable way. No one has contributed more than Mr. McComb to the sound growth of the NACE, especially in connection with the essential details of organization and financing where his broad experience and sound judgment have been invaluable.

Every effort should be made to continue the good work in the organization of local sections. The activities of local sections are of prime importance in making the association useful to its members. They provide frequent opportunities for members to get together for the first hand discussion of mutual problems. The local sections also represent the best means of showing prospective members the advantages of belonging to the NACE. They also serve as a training ground for future officers of the association and as a source of working members of the several technical committees.

The problem of deciding how best to finance the activities of local sections has been a difficult one to solve. No one procedure was favored by any large majority of the members who voted on an expression of opinion ballot.

The board of directors recently has acted to provide funds for the local sections to be spent in part for the purposes now allowed by the regulations, and in part for any other purpose that will advance the interests of the local sections and the NACE.

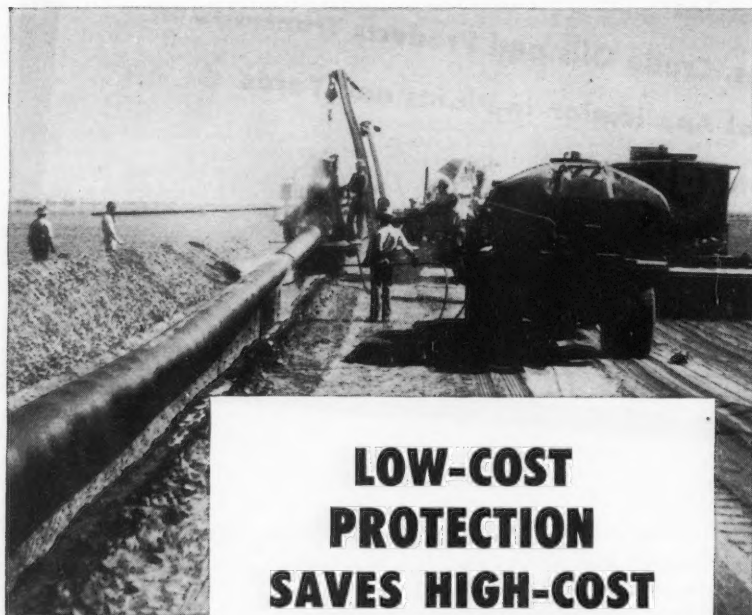
### Finances

Finally, it is very gratifying to report that the association is in excellent financial condition. Figures from the auditors' report for the year 1948 show that during 1948:

1. Current assets increased from about \$10,000 to about \$30,000.
2. Total assets increased from about \$12,000 to about \$36,000.
3. Net worth increased from about \$6,900 to about \$23,000.
4. Cash increased from about \$9,000 to about \$26,000.

The improved financial position did not result from any decrease in expenditures for the necessary activities of the association. Total expenditures for 1948 were about \$78,000, up \$18,000 from \$60,000 in 1947. In considering these expenditures, it might be well for the active members of the Association to note that if the \$78,000 spent in 1948 were to be divided by the number of active members at the end of 1948, it would show an expenditure of about \$53 per active member. This, of course, represented a very considerable extension of the \$7.50 which each active member paid as his annual dues. The spread was made up, of course, by the

(Continued on Page 14)



## LOW-COST PROTECTION SAVES HIGH-COST REPLACEMENT

**W**HEN a steel pipeline, thousands of miles long, goes into the ground, it must have permanent protection against corrosion. Replacement is a costly operation.

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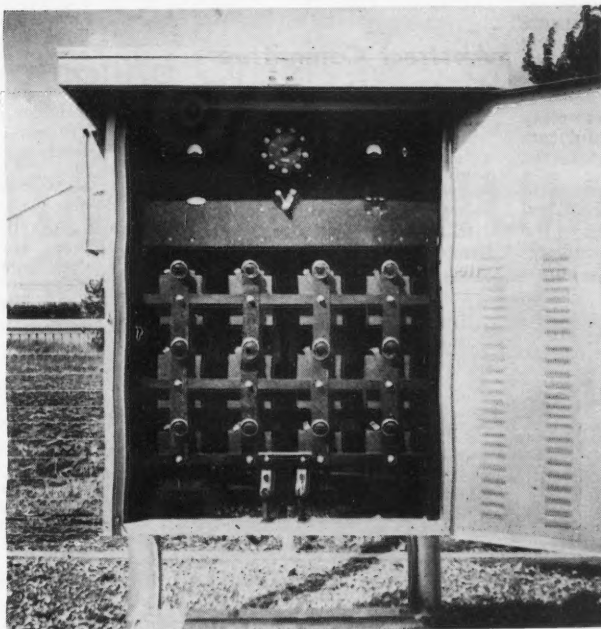
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## Steady Growth

(Continued from Page 12)

dues from the company members (which now total to about twice the active membership dues), receipts from advertising in Corrosion, sale of publications and the excess of income over expense at the annual conferences. The fact that so much was accomplished with the funds that reached them from these several sources reflected the administrative ability of our executive secretary Barry Campbell and the watchful care of our always dependable treasurer, O. C. Mudd.

I wish to have you recall what should have been evident from my remarks, that progress during 1948 in each of the departments that I have mentioned was due primarily to the enthusiastic efforts

of the individual members concerned with each activity. The best I can wish my successors in this office is a continuation of this kind of support and with it, and as a result of it, a bright future for the National Association of Corrosion Engineers.

## Abstract Committee Reviews New Index

The abstract committee met for an extended session Tuesday during the conference and concluded its suggestions for revisions of the preliminary abstract index at a later meeting.

Changes decided on in the item-by-item consideration of the proposed index will be incorporated into a revision

## Technical Practices Committee Reports

In the past the membership of the Technical Practices Committee has been made up of two groups of people—those appointed by the chairman of the committee and the chairmen of the various technical committees. Since there are now thirteen technical committees, it is suggested that in the future the Technical Practices Committee consist solely of a chairman, a vice-chairman plus the chairmen of the various technical committees. It is further suggested that these various technical committees have a broad field of work assigned to them and that specific problems can then be handled by sub-committees of the main technical committee.

For example, we now have three committees working on various phases of cathodic protection. It is suggested that these be considered as sub-committees of a main technical committee whose scope is the entire field of cathodic protection.

At the present time there are thirteen technical committees in various stages of development. Their status will be summarized briefly below. Each committee has been assigned a code number to make identification easier.

**TP-1 Corrosion of Oil and Gas Well Production Equipment** (W. F. Rogers, chairman) (Former title—Condensate Well Corrosion)

This committee has completed its initial assignment. It has prepared a detailed report of its findings which will be published in the near future.

The committee is being organized with a new title (given above) and a broader scope.

**TP-2 Galvanic Anodes** (M. C. Miller, chairman)

An interim report, including data obtained to date from the galvanic anode installations sponsored by this committee, has been prepared and will be published in the near future.

The committee is being organized with a new title (given above) and a broader scope.

**TP-3 Anodes for Impressed Currents** (D. H. Bond, chairman)

A preliminary report, giving the initial results of field tests, is now being prepared for publication.

(Continued on Page 16)

which will be circulated among members of the committee for further consideration.

Tentative decisions with respect to services to be offered through the development of the index and the key sort cards on which it is proposed the abstracts be recorded permanently include arranging to offer the abstracts already coded according to the NACE code to interested firms or individuals doing corrosion work. Annual publication of abstracts will continue as in the past.

Abstracts for 1946 now being assembled will be indexed according to the scheme now under review and publication of the abstracts in bound volumes is anticipated by the end of the year.

Present for the meetings were Miss Marguerite Bebbington, chairman, Dr. Ivy Parker, Dr. Norman Hackerman, Hugh Goddard, Dr. C. K. Eilerts and L. G. Vande Bogart.

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## Technical Practices

(Continued from Page 14)

### TP-4 Minimum Current Requirements for Cathodic Protection (A. V. Smith, chairman)

A survey of the methods now in use for determining the minimum current requirements for cathodic protection has been completed. The committee's report on this survey will be published in the near future. The committee is meeting April 11 in order to plan appropriate field tests.

### TP-5 Corrosion Problems in Processing and Handling Chemicals (M. G. Fontana, chairman)

This committee has formed several sub-committees in order to study vari-

ous phases of their broad assignment. The activities of these various sub-committees are summarized below.

### TP-5A Materials for Handling and Manufacturing Sulfuric Acid (S. W. Shepard, chairman)

Information being obtained. Expect to have a substantial amount of information for the April meeting. Method of presenting accumulated data will be discussed in April.

### TP-5B Design of Equipment for Corrosive Services (C. M. Shigley, chairman)

Questionnaire and topics for consideration prepared and sent out.

### TP-5C Sub-Surface Corrosion by Alkaline Solutions (H. W. Schmidt, chairman)

Questionnaire prepared and sent out to a selected list of individuals.

### TP-5D Corrosion by Organic Acids and Bases in the Vapor Phase (F. L. Whitney, chairman)

Questionnaire prepared and sent out. TP-5E Gasket Materials for Corrosion Service. (L. D. Cook, chairman)

### TP-6 Protective Coatings (G. W. Seagren, chairman)

This committee is meeting on April 13 in order to draw up a specific program of activity.

### TP-7 Materials for Use at High Temperatures (M. A. Scheil, chairman)

Questionnaires on carburization and decarburization have been sent out. At the meeting on April 12 a specific program of experimental work will be outlined.

### TP-8 Corrosion by Waters (V. V. Kendall, chairman)

At the meeting on April 13 a definite program of activity will be prepared.

### TP-9 Corrosion Inhibitors (A. Wachter, chairman)

This committee is having an organization meeting April 13.

### TP-10 Corrosion Fatigue (V. V. Kendall, chairman)

This committee is meeting on April 13. It is cooperating with the API committee on Corrosion Fatigue of Sucker Rod Materials. It will outline a cooperative program at the meeting.

### TP-11 Identification of Corrosion Products (C. M. Schwartz, chairman)

This committee is having an organization meeting on April 13.

### TP-12 Electrical Grounding Practices (H. L. Hamilton, chairman)

This committee has completed its initial assignment on corrosion problems arising from positive polarity grounding of d-c supply equipment. Its report will be published in the near future. The committee is now being reorganized in order to undertake new work.

### TP-13 Annual Losses Due to Corrosion (K. G. Compton, chairman)

This committee is holding an organization meeting on April 13.

(Signed)

R. B. MEARS, Chairman  
Technical Practices Committee.



Three methods are widely used to prevent corrosion — protective coatings, special alloys and chemical inhibitors. Each has special merit under certain conditions; but, when water, quiescent or recirculating, remains in contact with ordinary metals, a chemical inhibitor is generally indicated.

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## Committee Sessions

### TP-3

A subcommittee will be appointed to prepare for general circulation field reports on tests conducted by Technical Practices Committee 3 on Anodes for Impressed Currents, it was decided at the group's meeting during the Cincinnati conference. Sessions of the committee, under chairmanship of A. W. Peabody, acting in the absence of Donald Bond were attended by 37.

Reports on the test ground beds installed at four sites by the committee were presented by J. P. Oliver and W. Palmquist. Interim reports indicated an advantage in using carbon or graphite anodes over steel pipe and many advantages from the use of specialized backfill.

Future work of the committee also was discussed.

(Continued on Page 17)

## Committee Sessions

(Continued from Page 16)

### TP-4

A subcommittee was appointed to study the research problem of Technical Practices Committee 4 at its first meeting at the annual Conference in Cincinnati. The committee, on minimum Current Requirements for Cathodic Protection, held its first session at 9 a.m. Monday, April 11 and adjourned following extensive discussion by 37 members present of the report on questionnaires circulated by the committee among members of NACE. Future objectives within the scope of the committee's work also were discussed.

Appointed to the sub-committee by Chairman A. V. Smith were Dr. Harold F. Haase, Dr. John M. Pearson, Raymond F. Hadley, Scott Ewing, Kirk H. Logan and Harold A. Robinson.

A second session of the committee was scheduled for Tuesday, April 12.

Proposed outlines for research presented by the subcommittee at the group's second meeting consisted of a program calling for tests using a constant current over a period of time for each of a number of potentials, gradient measurement criteria, and an experiment to determine the degree of protection afforded by automatic apparatus.

### TP-5

Subcommittees of Technical Practices Committee 5 on Corrosion Problems in Processing and Handling Chemicals presented analyses of their findings from questionnaires circulated in the chemical industry. These reports dealt with stress corrosion, caustic embrittlement, sulfuric acid corrosion, corrosion by organic acids and gasket materials for corrosion service.

An extensive discussion was held concerning procedure for circulating questionnaires in order to achieve maximum results.

Dr. Mars G. Fontana presided over the 44-member meeting.

### TP-6

NACE membership will be circularized by Technical Practices Committee 6 on Protective Coatings to determine the interest in a compilation of standardized specifications on coatings. This decision was reached after a report of the policy committee on future work of the committee was presented and a proposal by Mr. Kenneth Tator, Coropolis, Pa., engineer was read.

Mr. Tator suggested an extensive review of practices in the protective coating field.

Results of the survey of the association's membership will be analyzed and presented the committee, after which manufacturers will be asked to submit data for the compilation of a report. The completed report will be distributed to engineers who are interested in this field.

Dr. George Seagren presided.

### TP-7

Material collected and evaluated by Technical Practices Committee 7 for Metals for Use at High Temperatures will be of substantial value to industry and especially in the growing field of rocket and jet propulsion engines, members of the committee agreed Wednesday, April 13, in Cincinnati at the annual conference.

Major decisions with respect to the future activities of the committee were as follows:

1. Primary function will be to compile data.
2. Tests will be conducted when and if funds and facilities are available.
3. Committee members were urged to send available data to the secretary.

4. Division of the task of evaluating the data will be made later.

5. Data dealing with conditions involving a 400° F. minimum temperature only are wanted.

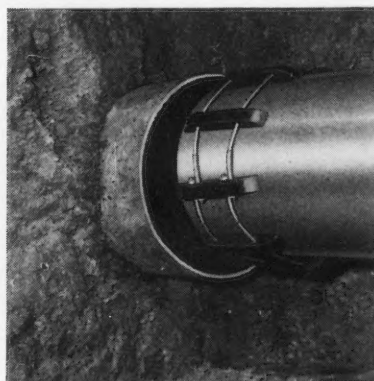
Returns from a questionnaire circulated by the committee on carburization and decarburization were analyzed and it was concluded data was insufficient to permit conclusions being drawn.

A. O. Crobaugh of Curtiss-Wright Corp. Rocket Research Division asked for information on corrosion that might be anticipated under certain defined conditions in rocket propulsion units and several suggestions for materials to be used were given him.

M. A. Scheil presided as chairman.

(Continued on Page 18)

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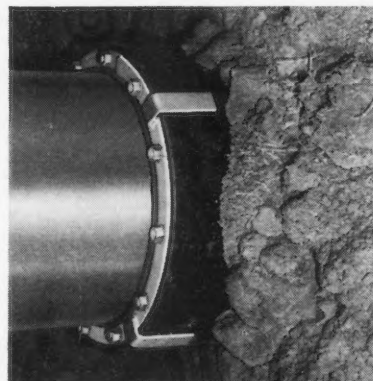
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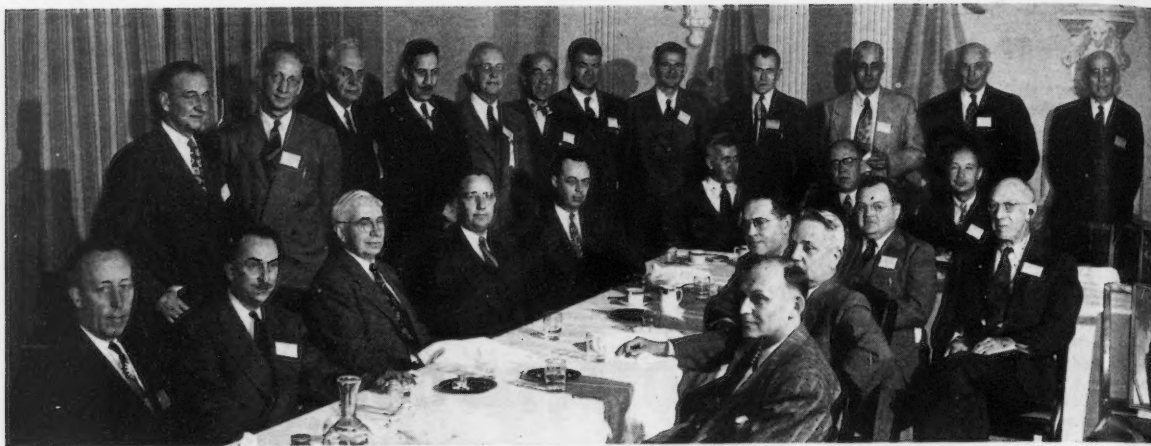
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## Inter-Society Committee Luncheon Is Held



### TP-6 Meets at Cincinnati



### Committee Sessions

(Continued from page 17)

Use of inhibitors in preventing corrosion in acid pickling, cooling water, oil pipelines, degreasing plants, boiler water, chemical processing plants and lubricating systems will be investigated by Technical Practices Committee 9 on Corrosion Inhibitors. This decision was reached in Cincinnati Wednesday, April 13 at a meeting attended by 29 presided over by Dr. A. Wachter.

The committee plans to circulate a questionnaire among inhibitor specialists to determine what practices are prevalent.

### TP-13

Annual losses from corrosion in eighteen classifications of industry will be investigated by eighteen sub-committees of Technical Practices Committee 13 on Annual Losses Due to Corrosion, it was decided at the meeting of this association subdivision at the Cincinnati conference. Chairmen to head subcommittees will be men presently engaged in the fields of the committees to which they are appointed.

These industrial classifications are: Nickel, lead, zinc, copper, brass, steel,

light metals, magnesium, pipe lines, marine structures, petroleum, heavy chemicals, communications, utilities, waterworks, foodstuffs, transportation and pulp and paper.

Members of the committee meeting with Chairman K. G. Compton recognized the enormous task confronting them, conceded it would take a number of years to get data in usable form, but agreed the survey would be of great value to industry providing it was thoroughly prepared and properly presented.

The August meeting of United Nations will undertake a project concerning annual losses due to corrosion in which Dr. H. H. Uhlig has been asked to present a paper. Mr. Frank LaQue, president of the association also will present a paper on other aspects of corrosion.

Dr. Uhlig, summarizing briefly for the committee data he plans to present to the United Nations, gave as his estimate of the direct annual loss due to corrosion in the United States the sum of approximately \$6,732,000,000.

Approval of arrangements by the national and local committees for the 1949 conference was voiced by numerous members of the association to the NACE staff.

### Inter-Society Group Discusses Testing

The standard test specimen program being conducted by the Inter-Society Corrosion Committee was discussed by 24 members of the group gathered for a luncheon meeting during the 1949 NACE conference in Cincinnati. Dr. H. H. Uhlig acted as chairman of the meeting.

Other discussion by the group included annual reports to be submitted by associated societies to publicize their corrosion activities and coming meetings, in order that duplication of work and conflicts in schedules might be minimized.

### Policy is Defined On Printing Reports

Decisions reached at the meetings of the old and new boards of directors during the Cincinnati conference with respect to the manner in which reports of technical committees are to be handled include the following:

1. Major reports are to be published separately.
2. Minor, interim and relatively short reports will be either:
  - a. Published separately, if interest in them justifies it.
  - b. Published in CORROSION magazine.
  - c. Published in bound volumes of committee reports.
3. Committee reports will be offered in bound volumes at intervals when the volume available justifies binding of collected reports.

Notification of imminent publication of reports and approximate price will be given in CORROSION magazine. Those interested should address inquiries to the Central Office in Houston.

The several final and interim reports now in the hands of the Technical Practices Committee will be released for publication soon, it was announced.

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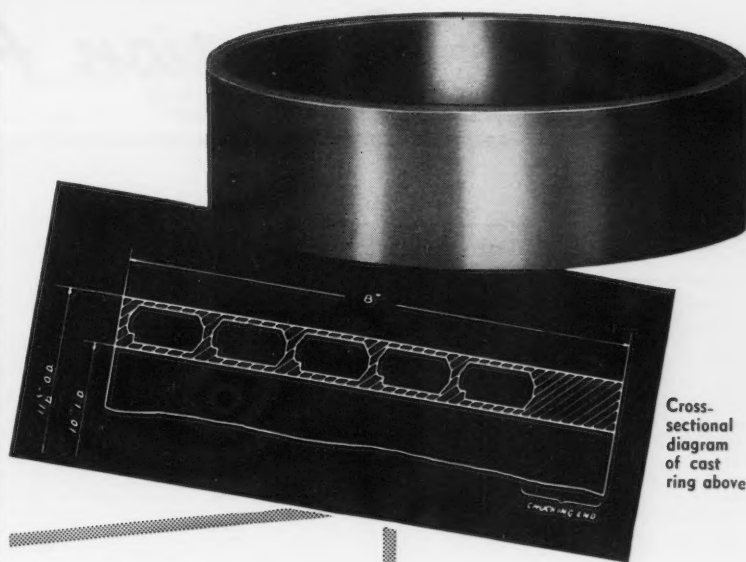
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# Corrosion Abstracts

## BEARING

**Scanning the Field for Ideas—Corrosion Resistant Bearings.** *Machine Design*, 19, No. 11, 108 (1947) Nov.

The corrosion-resistant bearing described is a special extra-hard porcelain enamel-on-steel backing and the journal is a series of synthetic rubber sleeves fitted over the shaft. These outwear common rubber bearings with Monel sleeves about 5:1 and oil lubricated bearings about 25:1. The synthetic rubber journal is self lubricating, revolving against the porcelain with a minimum of wearing friction. It is molded in sections  $\frac{3}{4}$ -inch high and about  $\frac{1}{4}$ -inch thick. These sections are stacked to give any desired length. The journal sleeve has a hole smaller than the shaft and, when forced over the shaft, is sufficiently tight to revolve with it. Tubular walls of the porcelain-enamelled bearings are approximately  $\frac{1}{4}$ -inch thick and are turned smooth for a press fit into a spider. Designed by Caldwell Glass Bearings, Inc.—INCO.

**(Corrosion by) Additive Lubricating Oils.** *Mech. Eng.* 69, No. 2, 150-152 (1947).

Factors entering into the corrosion of alloy exhaust-valve guides, causing excessive clearances are: 1) rocker-arm oil-base temp., 2) valve guide temp., 3) valve-guide composition, and 4) oil composition. High-temperature stability of lubricating oils and especially of their

## Abstract Section Style Outlined

For ease in locating reference data, CORROSION uses a uniform style in its Abstract Section.

The abstracts first are broken down into major classifications of the more common types of corrosion literature. In each review the title of the article is presented in bold face type, followed by the author's name. The publication from which the article was abstracted is printed in italics and is abbreviated in most instances. Following this, in sequence, are the volume (bold face), number in the volume, pages, year and month of publication. In some instances a second reference will be listed in the same manner. This indicates that the article also was published or abstracted in another publication. A brief summary of the article follows the above information and it is concluded with an abbreviation indicating the source of the abstract and contributor. The meanings of these abbreviations usually are listed on the first page of the Abstract Section.

When seeking more detailed data about an abstract, best source of information is the publication in which the article appeared originally. (Listed in italics in the heading.) The contributor of the abstract also may be able to supply additional information. Addresses of most of these publications may be found in the reference section of most public libraries.

additives appears to be of the first importance.—MA.

**Inhibitor Action in Crankcase Lubricants.** A. F. Prutton. *Oil and Gas J.* 47, 70-73, 103 (1948) June.

Considers functions of a crankcase lubricant and gives details of factors involved in producing a lubricant which will be relatively non-corrosive toward copper-lead allow bearings.—BLR.

**Mechanism of Action of Bearing Corrosion Inhibitors in Crankcase Lubricants.** J. D. Guttenplan and C. F. Prutton. *Lubrication Eng.*, 4, 125-131; discussion, p. 131 (1948) June.

Presents results of studies on oxidizing agents in oil which may be chemically or catalytically destroyed by the inhibitor and on the formation of surface film on bearing material by the inhibitor. Includes tables of results on modes of action of five inhibitors on copper-lead bearing metal. 15 ref.—BLR.

## CHEMICAL

**Corrosion (Acetic Acid).** M. G. Fontana. *Ind. Eng. Chem.*, 40, No. 7, 73A-74A (1948) July; 40, No. 8, 71A-72A (1948) Aug.

Materials of construction for manufacturing and handling plant for acetic acid. Useful concise summary including data on corrosion of various metals obtained during laboratory work at Ohio State University, where an investigation on the subject is taking place. Existing experience is summarized; no literature references. Actual cases of corrosion in plants handling the hot acid are described in the August instalment.—BNF.

**The Breakdown of Oxide Films in Acid Vapors.** W. Feitknecht. Pittsburgh International Conference on Surface Reactions, Pages 212-221 (1948) June.

Some facts about the corrosion of iron, zinc, cadmium, nickel and copper in air containing hydrogen chloride-vapor are summarized. Three kinds of the breakdown of the primary oxide film can be distinguished. In the first (iron and nickel) the primary oxide film breaks down only at isolated points; in the second (zinc and cadmium) the whole film breaks down and grows thicker; in a later stage this thicker film is attacked at isolated centers. The first stages of the breakdown of the primary oxide film on zinc and copper is studied with the help of an electron microscope.

An electrochemical mechanism of the breakdown of the primary oxide film and the atmospheric corrosion due to acid vapors is proposed. The peculiarities of every single case can be understood, if the chemical, thermochemical and kinetic properties of the possible solid corrosion products are taken into account. Principal facts on the chemical properties of the corrosion products observed on iron, nickel, zinc and copper are put together and the mechanism of the corrosion of these metals is discussed in detail. (Author's summary.)—ALL.

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**The Dissolution of Aluminum in Sodium Hydroxide Solutions.** M. A. Streicher. *J. of the Electrochem. Soc.* 93, No. 6, 285-315 (1948) June.

The effect of immersion time, temperature, concentration, and an applied external current on the dissolution of commercially pure aluminum in sodium hydroxide solutions is described. A technique resulting in reproducible dissolution rates is given. The instantaneous rate of dissolution increases at a decreasing rate with immersion-time and is directly proportional to the weight-loss and inversely proportional to the immersion-time. The effect of temperature on the rate of dissolution is given by the Arrhenius equation. It is shown that the changing rate and electrode po-

tential are determined by the precipitate which forms local cathodes on the surface of the metal during dissolution. The electrode potential varies as the rate of dissolution, a measure of the local cell current, varies.

When aluminum is made cathodic in sodium hydroxide solutions, the rate of dissolution is decreased only slightly. Making aluminum anodic in sodium hydroxide solutions gradually eliminates hydrogen evolution at the anode as the current density is increased until it is stopped entirely (local cell action is suppressed), and the weight-loss is electrochemically equivalent to the external current. This decrease in local cell action (normal dissolution) is directly pro-

portional to the anodic current density and is reproducible.

It is found that the various phenomena accompanying the dissolution of aluminum in sodium hydroxide solutions, as described in this paper, may be explained in terms of electrochemical theory. 45 references.—ALL.

**The Corrosion of Silver by Bromine.** (In German.) R. Weiner. *Arch. Metallkunde*, 1, No. 6, 281-284 (1947).

A study was made of the corrosion of fine silver by dry and wet pure bromine and bromine containing small quantities of various impurities. The results show that in all cases an adherent film of silver bromide is always formed. The rate of attack initially follows a parabolic law, but later becomes linear; it never actually ceases or retards so much that it can be said to be almost at a standstill. Presence of water or

**STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912 AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 OF CORROSION, PUBLISHED MONTHLY AT HOUSTON, TEXAS, FOR APRIL 1, 1949.**

STATE OF TEXAS  
COUNTY OF HARRIS

Before me, a Notary Public in and for the State and county aforesaid, personally appeared A. B. Campbell, who, having been duly sworn according to law, deposes and says that he is the Executive Secretary of the Corrosion and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily, weekly, semiweekly or triweekly newspaper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the act of August 24, 1912, as amended by the acts of March 3, 1933, and July 2, 1946 (section 537, Postal Laws and Regulations), printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, National Ass'n of Corrosion Engineers, 711 Main St., Houston, Texas.

Editor, Dr. Ivy M. Parker, P. O. Box 423, Bremen, Georgia.

Managing editor, N. E. Hamner, 711 Main St., Houston, Texas.

Executive Secretary, A. B. Campbell, 711 Main St., Houston, Texas.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) The National Association of Corrosion Engineers, Houston, Texas. A non-profit organization, therefore no stock issued.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affirmant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

A. B. CAMPBELL, Executive Secretary  
Sworn to and subscribed before me this 22nd day of March, 1949.  
(Seal) ANN GRAHAM  
(My commission expires June 1, 1949)

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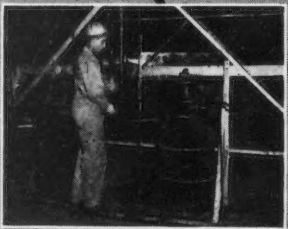
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various anions does not, surprisingly, noticeably increase the rate of attack, but the presence of bromine ions or traces of iron greatly accelerates the attack, and, in this case, rapid destruction of the metal takes place. When impurities are absent and the silver bromide film adheres firmly to the metal, the rate of penetration does not exceed more than a few hundredths of a millimetre a year. Approximate rates of penetration per year are 1) pure, dry bromine 0.03 mm., 2) dry bromine with traces of iron 0.06 mm., 3) dry bromine and hydrogen bromide 0.1 mm., and 4) damp bromine with traces of iron 0.17 mm. 11 references.—MA.

**Electrochemical Study of Corrosion of Metals in Ethylene Glycol Solutions.** N. D. Tomashov and M. A. Timonova. *J. of Physical Chem. (U.S.S.R.)* 22, 221-231 (1948). *Chem. Absts.* 42, No. 14, 4894 (1948) July 20.

Cathodic polarization of copper and iron in 55 percent aqueous glycol is determined by depolarization by dissolved oxygen. The limiting current density  $i_0$  is at 16°C. (60.8°F.) 0.005 ma./sq.cm. for both metals. The cathodic polarization of aluminum is complicated by solution of the oxide film. Addition of water lowers the hydrogen overvoltage and raises  $i_0$ ; in pure water,  $i_0 = 0.015$  ma./sq.cm. Anodic polarizability of copper, iron, and aluminum is very small. Calculation of the potential drop in the local cells shows corrosion in aqueous glycol is determined mainly by the cathodic polarization, the ohmic drop of potential being negligible except when

dissimilar metals are separated by several centimeters. This is important for corrosion by antifreeze solutions. The corrosion inhibitor V-2 containing dextrin and phosphate (no exact composition given) little effects the cathodic polarization of copper, iron, and aluminum in 55 percent glycol but raises the anodic polarization, e.g., from 0.2 to 1.5 v. Phosphate seems to be the active ingredient of the inhibitor. In the presence of inhibitor, corrosion is determined by the anodic process.—ALL.

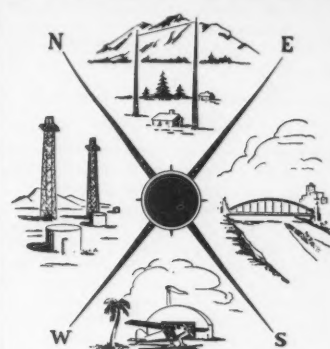
**Peculiarities of Reactions of Certain Organic Acids with Industrial Metals.** (In Russian.) V. D. Yakhontov. *Zhurnal Obshchey Khimii* (Journal of General Chemistry), 17, No. 79, 2054-2057 (1947) Nov.

Presents results of a study of the reactions of magnesium, zinc, aluminum and its alloys, lead, copper, and a carbon steel with formic, acetic, oxalic, and maleic acids.—BLR.

**Influence of the Orientation of Grain Boundaries of High-Purity Aluminum on their Attack by Hydrochloric Acid.** Nicolas Yannaquis and Paul Lacombe. *Compt. Rend.*, 226, No. 6, 498-499 (1948).

It already has been shown *ibid.*, 224, 921 (1947); *Met. Abs.*, 14, 381 (1947), that the rate of intergranular attack at the grain boundaries of high-purity aluminum is greatly influenced by the relative orientation of contiguous grains. The effect of the crystallographic factor and in particular that of the orientation of the boundary itself in relation to the crystals, have been further studied. The investigation showed relative

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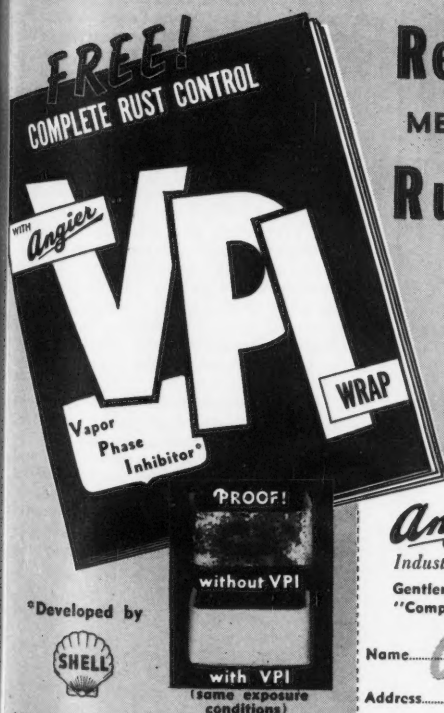
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orientation of contiguous crystals is not a sufficient condition for the resistance to attack at their junction: it is also necessary that the boundary of the grains should possess a definite orientation in relation to the two neighboring systems.—MA.

## COATINGS

**The Role of Paint in Combating Corrosion in the Petroleum Industry.** P. L. Lotz, Socony-Vacuum Oil Co. Preprint, A. P. I. Div. of Refg. 13th Mid-Year Meet., Philadelphia, 6 pp. (1948) May 11.

Paint combats corrosion by sealing off the steel surface from the corrosion environment and by altering the environment with pigmentations. Several types

of chemical resistant coatings have been developed to meet severe service requirements such as are found in the petroleum industry. Chlorinated rubber base paints show excellent alkali resistance but relatively poor resistance to fats, oils and solvents. Vinyl coatings are resistant to aromatic solvents, highly concentrated acids, and alkalis, but not to acetic acid. Vinyl coatings require strong toxic thinners, have a low solids content, requiring 5 or 6 coats for adequate protection, require a sand-blasted surface for satisfactory adhesion, and are ineffective at temperatures above 140° F. The solvent resistance of vinyl-latex dispersion coatings is superior to that of vinyls. Styrene coatings show excellent resistance to chemicals but poor resistance to solvents.

**The Measurement of Permeability Characteristics of Anodic Films on Aluminum.** R. L. Burwell, Jr., and T. P. May. Pittsburgh International Conference on Surface Reactions, 10-20 (1948) June.

Techniques have been investigated for quantitatively studying the permeability of anodic aluminum oxide by measurement of rates of diffusion of salts through the film, rates of osmosis using the film as the membrane, rates of water transport through the film and conductance of the film using salt solution as electrodes. These techniques have been applied in an exploratory fashion to anodic film prepared by complete anodization of aluminum foil and to film separated from anodized aluminum by action of solutions of mercuric chloride.

Film liberated by the mercuric chloride solution is the less permeable. Films of equal thickness prepared in chromic and sulphuric acids are about equally permeable. Continued exposure to anodizing electrolyte after anodizing results in considerable increase in permeability, while "sealing" in boiling water causes a hundred-fold decrease in permeability. In contrast to their very unequal corrosive action, potassium nitrate and potassium chloride penetrate the film at about equal rates.

It appears the film is not entirely penetrated by pores but that a residual, comparatively impervious barrier layer exists in the film.—ALL.

**Protective Films: Natural Formation on Aluminium and its Alloys.** F. A. Champion. *Met. Ind.*, 72, Nos. 22, 23, 440-442+ 463-464 (1948) May 28, June 4.

The author shows that whenever an alumina film is formed the corrosion follows an exponential law. Equations are derived and used to determine the ultimate corrosion rate from two measurements. It is considered that for comparison of different materials the above method applied to tests in neutral sodium chloride solution is superior to that of using more reactive corrodants. Experimental data is given. 19 references.

**Copper-Titanium Alloy Coatings on Mild Steel.** Edward J. Chapin and Carle R. Hayward. *Trans. Amer. Soc. Metals*, 38, 909-956 (1947).

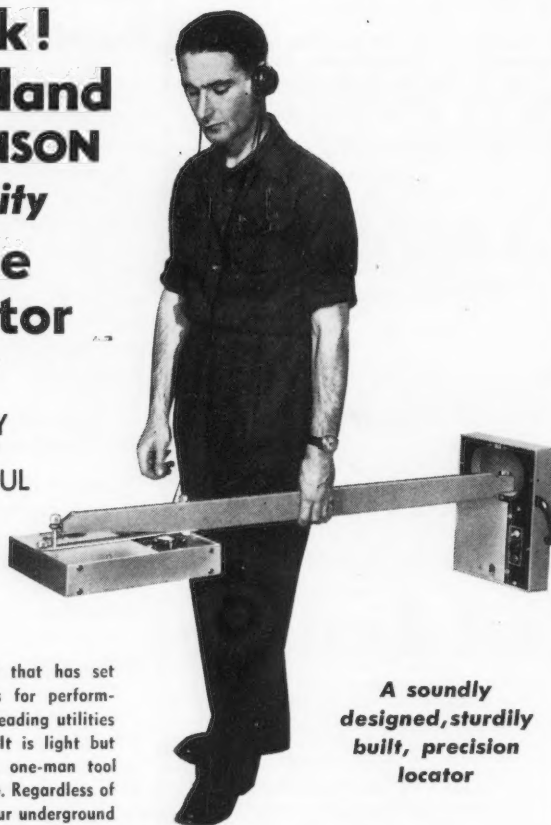
The properties and alloying behavior of titanium and previous work on titanium-bearing coatings on metals are reviewed. Samples of coated mild steel were prepared by heating in intimate contact with titanium hydride or a copper-titanium hydride mixture after suitable treatment, giving 5-37.5 percent titanium in copper alloy coatings. These coatings were resistant to corrosion in 10 percent sodium hydroxide at 35° C. The 25 percent titanium coating had the best (pearlitic) micro-structure and other properties. The constitutional features of the coating and the area of diffusion are discussed. Exceptionally hard, though brittle, coatings were obtained which responded further to nitriding treatment.—MA.

**Indium Coating to Protect Steel.** *Chem. Age*, 56, No. 1451, 569 (1947).

A thin coating of indium, electrodeposited, sprayed, or otherwise deposited on steel is highly corrosion-resistant.—MA.

**The Electrochemical Investigation of Metals Protected by Basic Coatings.** V.

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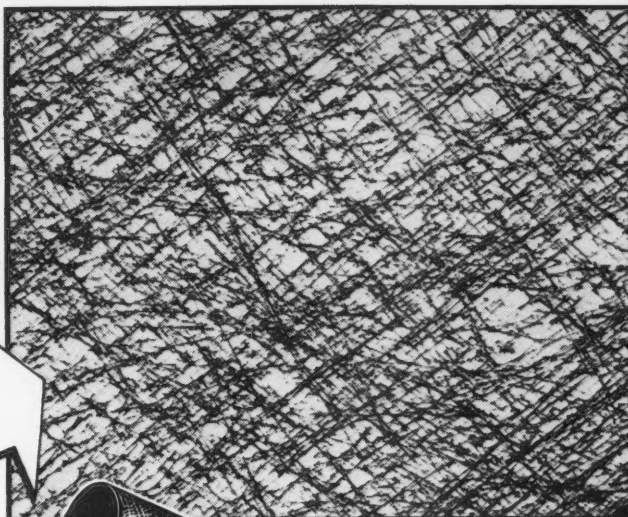
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Cupr. Arch. Metallkunde, 1, No. 6, 264-267 (1947).

The corrosion-resistance values of metal coatings, particularly those of phosphate or basic films are best determined by electrochemical methods. For a true appreciation of the values it is necessary to know 1) the potential of the metal and its dependence on the pH of the bath; 2) the c.d., on which depends the anodic and cathodic polarization effects and, therefore, solution of any oxide film present and 3) the electrical resistance of the coating. Methods of measuring these factors are described and, from the results obtained by such determinations, an attempt is made to assess the relative values of various coatings.—MA.

**Metal Surfaces — Their Preparation and Painting.** G. Diehlman, A. J. Eickhoff, and J. G. Wills. *Official Digest*, 357-367 (1948) May.

Reviews the various methods used for iron and steel, zinc (galvanized iron); and aluminum and its alloys. 13 references.—BLR.

**Studies on Anti-fouling Compositions.** H. Barnes. *J. of The Iron and Steel Inst.*, 159, Part 2, 175-185 (1948) June.

This paper forms part of a series of studies on anti-fouling compositions made by the Marine Corrosion Committee of the Metallurgy (General) Division of the British Iron and Steel Research Association. Following a discussion of the factors affecting the rate of release of cuprous oxide from anti-

fouling compositions, consideration is given to the methods of storage of leaching slides in order to compare anti-fouling behavior with leaching-rate determination. Sea storage is considered desirable when large numbers of compositions are to be tested. The relation between the loss on raft panels and that given by leaching-rate determinations has been investigated. By leaching-rate determinations and assessment data on replicate panels, the critical leaching rates necessary to prevent the establishment of some important fouling organisms have been determined for average exposure conditions. It is shown that a rate of 10 mg. sq. cm. per day will prevent the settlement of forms other than algae. Data are presented on the loss of copper from experimental compositions under varying conditions of service. It is shown that the loss in service is greater than that from the same composition when exposed on the raft.—ME.

**Drill Pipe Failures, Inspection, and Protection in the Permian Basin.** W. H. Crenshaw and others. *Petro. Eng.*, 14, 277-278, 280+ (1948) May.

Discusses some of the steps taken by drilling operators during the last two years toward reducing drill-pipe failures. A summary of the types of failures experienced and of the steps being followed to prevent them is given. Two of the most important of these steps, inspection and use of protective coatings are discussed in some detail.—BLR.

**Amercoat Stack Coating.** *Ind. Heating*, 15, No. 1, 124 (1948) Jan.

Amercoat No. 1132 stack coating for high temperature uses, based on silicone resins, able to withstand continuous heat up to 600° F. and resist corrosive chemical conditions and weathering. Mfd. by American Pipe & Construction Co.—INCO.

**Corrosion Inhibiting Primers for Ferrous Metals.** W. G. Huckle and H. S. Davidson. *Amer. Paint Jour.*, 32, 76-77+ (1948) June 28. *Paint, Oil & Chem. Rev.*, 14, 18+ (1948) July 22.

Describes experimental work designed primarily to determine what pigment or pigments give most satisfactory results when used with zinc chromate. Also studies relative effectiveness of various types of pigments; compares various types of binders; describes determination of amount of zinc yellow required for effective metal protection and compares several primers applied to sand-blasted, rusted, or mill-scaled steel surfaces.—BLR.

**Pore Volume of Electrolytically Produced Protective Coatings on Aluminum.** K. Huber. *J. of Colloid Science*, 3, 197-206 (1948) June.

Earlier microscope studies and electron photomicrograms taken by the author and other investigators show that protective oxide coatings produced electrolytically on aluminum have a structure closely similar to that of an ideal "columnar mixture" of Wiener. Therefore, an attempt is made to compute the pore volume, basing the computation on Wiener's theory. Determinations of the necessary optical properties of the coatings are reported.—BLR.

**Recent Investigations Into the Hot-Dip Tinning of Steel Spoons and Forks.** W. E. Hoare and K. W. Caulfield. *Sheet*

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PIONEERS IN STEEL PIPE PROTECTION

*Metal Ind.*, 25, No. 253, 925-930+ (1948)

After a brief description of present methods for hot-tinning tableware, details are given of an investigation to determine preferred procedures for the preparation, dip-tinning, and manipulation of these articles in volume production.—MA.

## CONSTRUCTION MATERIALS

**Metals Handbook: 1948 Edition.** American Society for Metals. Book, 1948, 1444 pp. Published by the Society, 7301 Euclid Avenue, Cleveland 3, Ohio. Price to members of the A.S.M. \$10; to non-members \$15.

This, the first revision since the pre-war 1939 edition, is very substantially altered and enlarged. The general section deals with physical data, shaping, jointing, testing, structure and properties, etc. (301 pages.) The ferrous metals section comprises 420 pages and the non-ferrous 405 pages (sections on aluminum and alloys, copper and alloys, lead and alloys, magnesium and alloys, nickel and alloys, tin and alloys, zinc and alloys, precious metals, etc.). The final section gives up-to-date phase diagrams of 242 binary and 42 ternary systems, in each case with recent references.—BNF.

**High Nickel-Chromium Alloys Increase Thermocouple Life.** *Instrumentation*, 2, No. 4, 29-30 (1947). *Ceramic Abs.*, 81, (1948) April.

Following alloys are used for high-temperature thermocouples: 80-14-6, 60-k4-26, 32-20-48 nickel-chromium-iron, and 28-72 chromium-iron; physical and corrosion data for these alloys and a table of time lags for various couples and protecting tubes are given.—INCO.

**Karbate Seven Tube Heat Exchanger.** *Ind. Heating*, 15, No. 5, 880 (1948) May.

Seven tube Karbate Impervious Graphite shell and tube heat exchangers for use under highly corrosive con-

ditions, can be used as heaters, coolers, boilers, or condensers, and can be operated vertically or horizontally. It has properties of high thermal conductivity and resistance to action of most acids, alkalis, and other corrosive, solvent or reducing agents. Mfd. by Nat. Carbon Co.—INCO.

**Progress in Alloy Steels.** H. J. French, International Nickel Co., Inc. Paper before AIME, N. Y. Section, (1948) Jan. 28. *Mining & Metallurgy*, 29, No. 498, 336-340 (1948) June.

Metals, including nickel, used and the properties they give to alloy steels are reviewed. Stainless steels and the corrosion resistance of alloy steels are discussed.—INCO.

**Study of Magnesium Alloy C2M, Resistant to Corrosion.** Hiroshi Asada and Hirotake Kikuchi. Report of the Aeronautical Research Institute, Tokyo Imperial University (Japan), No. 312, 232-265 (1944). *Chem. Abstr.*, 42, No. 13, 4509 (1948), July 10.

The alloy contained cadmium 3, zinc 1, manganese 1 percent. It had excellent mechanical properties: tensile strength 23-25 kg./sq.mm., ductility 23-30 percent, the least radius of curvature at the 180° bending was only 2.5-3.5 times larger than the thickness of the plates. The corrosive resistance was very superior to AM 537 made by Beck of the Lieger Co. in Germany.—ALL.

**High Density Alloy.** *Autom. Industries*, 98, No. 1, 54 (1948) Jan. 1.

G-E Hevimet, an alloy of tungsten, copper and nickel, possesses a density 50 percent greater than lead and is applicable to the design and construction of moving parts possessing maximum inertia and minimum size. It is adaptable to the construction of balance weights for the elimination of vibration in crankshafts, modern air screws, centrifugal clutches and other rotating parts. Combining great tensile strength with good machinability, G-E Hevimet is said to be highly resistant to atmospheric salt water corrosion and easily

plated with cadmium, chromium and nickel. Mfg. by General Electric.—INCO.

**The Application of Electrochemical Cells to the Determination of Oxygen Dissolved in Water and to the Indication of Corrosion.** F. Tödt. *Archiv. für Metalkunde*, 1, Nos. 11-12, 469-471 (1947) Nov.-Dec.

Author discusses value of current measurements in certain cells for the determination of concentration of oxygen and for the measurement of corrosion rates and, therefore, for the assessment of the efficacy of protective coatings. No precise details but literature references.—BNF.

**Marine Corrosion Testing.** Frank N. Speller. Blast Furnace and Steel Plant, 36, 950-953 (1948) Aug.

Gives review of discussions of marine corrosion testing.—BLR.

**Passivity and Chemical Stability of Chromium Alloys.** B. V. Stark and S. I. Filippov Henry Bruther (Altadena, Cal.). Translation No. 2094, 1948, 11 pages. From *Stal'* (steel), 7, No. 5, 439,422 (1947).

Discusses the mechanism of passivation and the relation between passivity and corrosion resistance, based on anodic and cathodic polarization of chromium alloys under a drop of electrolyte. Describes experimental apparatus and procedure.—BLR.

**Engineering Characteristics of 61S Aluminum Alloy Sheet.** Joseph J. Waga. *Prod. Eng.*, 19, 108-112 (1948) June.

Describes fabricating and engineering properties of sheet Aluminum-magnesium-silicon alloy 61S. Includes data on heat-treatment; mechanical properties of sheet both without and with heat-treatment and in work-hardened conditions; and resistance to corrosion. Discusses welding and forming characteristics of the alloy sheet.—BLR.

**Various Methods of Studying the Behavior of Alloys in Rapidly Flowing Sea-Water.** F. L. LaQue and W. C. Stewart. *Metaux & Corrosion*, 23, No. 274, 147-164 (1948) June.

Describes three forms of apparatus in operation at Kure Beach, U. S. A., with notes on the behavior of bronze and cupro-nickel (including effect of small amounts of iron on 70/30 cupro-nickel).—BNF.

**Cast Nickel-Molybdenum and Nickel-Molybdenum-Chromium Alloys for Severe Corrosion Services.** Walter A. Luce. *Chem. Eng. Prog.* (Transactions Section), 44, 435-457; discussion, 457-458 (1948) June.

The author is associated with The Duriron Co. Data presented were obtained on high nickel-molybdenum and high nickel-molybdenum-chromium alloys with an alloy content of approximately 97 percent. Outgrowth of this work has been the introduction of two alloys designated as Chlorimet 2 (nickel-molybdenum) and Chlorimet 3 (nickel-molybdenum-chromium). Contains the results of many laboratory and plant investigations on corrosion resistance and application of these alloys.—BLR.

**Stainless Steel Piping—Why and Where to Use It—Selection of Pipe Joints—Fabrication by Welding.** J. D. Mattimore, Tube Turns, Inc. *Heating*,

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*Piping & Air Conditioning*, 19, No. 10, 81-83 (1947) Oct.; No. 11, Nov., 84-87; No. 12, 73-78, Dec.

Reasons for the use of stainless steel piping for different applications and the selection of types 304, 347, and 316 as meeting 95 percent of industry's needs are discussed. Attention was called to the standardization of lighter wall thickness for stainless pipe and fittings. Considerations in selecting types of joints for maintaining sanitary condition, avoiding fluid contamination and reducing the possibility of crevice type corrosion are given. Preparation of stainless pipe joints for welding, welding processes, and heat treatment after welding are described.—INCO.

## GENERAL

**Crane Co. Announces New Alloy Valve Line.** H. J. Bartlett. *Valve World*, 45, No. 1, 9, (1948).

The recently announced corrosion-resistant alloy plug gate valves are available in either Crane 18-8 molybdenum alloy steel or in Monel metal.—INCO.

**On the Corrosion of Magnesium-Manganese Casting Alloys and Semi-Products.** A. Beerwald. *Arch. Metallkunde*, 1, No. 6, 284-285 (1947).

A study was made of the corrosion-resistance (against 1 percent sodium chloride solution) of cast, forged, or rolled binary magnesium-manganese alloys in the as-cast condition or after heat-treatment at 1) 250°C for 24-48 hours and furnace cooling, or 2) 550°C for 24 hours and quenching in water.

It is shown that 1) the maximum corrosion-resistance is attained at 0.9 percent manganese; above this value the manganese content is without influence on the corrosion properties; 2) the greatest rate of corrosion occurs with alloys containing <0.9 percent manganese after solution treatment at 550°C; and 3) in contrast to pure magnesium and aluminum-containing magnesium alloys, the presence of up to 0.02 percent iron in the binary magnesium-manganese alloys has no influence on the corrosion properties, so long as the manganese content is <0.9 percent.—MA.

**Aluminum and Aluminum Alloys in the Food Industry.** J. M. Bryan. Dept. Scientific and Industrial Research Food Investigation Special Report 50, 153 pp. (1948).

Properties of aluminum and aluminum-base alloys behavior in contact with acids, alkalis, water, dissolved salts, corrosion by food products (fruit and vegetables, beverages, meat and dairy products) aluminum packaging materials, and methods of protecting by oxide coatings, metallic coatings, cathodic protection and non-metallic coatings are discussed.—INCO.

**The Detection of Corrosive Sulfur Compounds in Mineral Transformer Oil.** Frank M. Clark and Edward L. Raab. *A.S.T.M., Preprint No. 87*, 10 pages (1948).

Discusses the limitations of A.S.T.M. method D117 for detection of combined sulfur and presents results of a study of the various factors involved. Then describes a method in which the oil is heated in the presence of a clean copper surface for 19 hours at 140°C. The amount of copper sulfide formed is considered to be proportional to the corrosive sulfur content. Also describes spectrophotometric determination of the amount of sulfur deposited on the copper strips in the General Electric method of test.—BLR.

**Corrosion Research in Union-Castle Ships.** *The Shipping World*, 118, 517 (1948) May 26.

The activities of the corrosion Committee of the British Iron and Steel Research Association were discussed at a recent meeting in Birmingham. The effects of internal corrosion in marine boilers, flame cleaning of ship plates and the corrosion of underwater surfaces of ships are but a few of the many fields covered by the various sub-committees. The Marine Corrosion Sub-Committee, with Professor J. E. Harris as chairman, has made a detailed study of the prevention of corrosion by sea water and the prevention of fouling. In the prevention of corrosion by sea water considerable advances are claimed in the development of efficient protective paints. As a result of a series of researches, a number of anti-corrosive compositions have been developed which are now regarded as setting up a reasonable standard of efficiency. One of these compositions has been used by the Admiralty with satisfaction, and it is of special interest to note that the outer hull plating of the "Pretoria Castle" and the "Edinburg Castle," built by Harland and Wolff, Ltd., Belfast, for the Union-Castle Mail Steamship Co., Ltd., were painted on the stocks with compositions and paints to the sub-committee's specifications. The "Edinburg Castle" has not yet been drydocked since fitting out, but the "Pretoria Castle" was drydocked

a few weeks ago, seven months after fitting out and the effect of these compositions noted. On inspection, 98 percent of the bottom paint was found to be perfectly intact and unstained by rust.—Eng. Abst.

**Long Term Metals Corrosion Investigation.** U. S. Panama Canal, Special Eng. Div., First Interim Report No. 74, 78 pp, Appendix 1, 167 pp. (1947) Jan.

Significant information and data relating to major corrosion investigation of 52 different metal types, including steels, stainless steels, copper-nickel, Monel, and nickel. Embraced are tropical fresh-water, sea water, and atmospheric exposures. Compilation includes organization and initiation of plan, exposure sites, environment and durations, design of equipment and apparatus, processing and installation of specimens, inspections, tests of metal samples and marine growths and physical properties, analysis of metals, immersion media and corrosion products and an extensive bibliography. The appendix contains photographs, tables and graphs to illustrate.—INCO.

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## INHIBITORS

**An Evaluation of Inhibited Turbine Oils Versus Uninhibited Turbine Oils for Turbine Lubrication.** M. D. Baker, West Penn Power Co. Paper before A.S.T.M. Tech. Comm. C on Turbine Oils of Comm. D-2 on Petroleum Products & Lubricants, Symp. on Service Experience with Inhibited Turbine Oils, Washington, D. C., Feb. 9, 1948, *A.S.T.M. Bull.*, No. 152, 59-61 (1948) May.

Oxidation inhibited oils have given satisfactory service for steam turbine lubrication since 1936, and oxidation and corrosion inhibited oils since 1943. All steam-driven prime movers on the system are lubricated with these oils. Service life of the oxidation inhibited oils was at least three times the life of uninhibited oils under severe conditions. Under normal conditions the life was not determined. Oil coolers are cleaner and need very infrequent cleanings. When cleaning is needed, it can be done without resorting to chemical cleaners. Filter bags have about 5 years' service between cleanings. During overhaul periods no radical cleaning is needed for the oil system. Corrosion was eliminated.—INCO.

**Rust Prevention in Products Pipe Lines.** E. W. Unruh and F. M. Watkins. *Oil and Gas J.* 47, 63-64+ (1948) June 17. Describes properties and uses of Sinclair RD-119, a new rust inhibitor recently developed and tested on a commercial basis. Gives results of laboratory tests.—BLR.

**Practical Use of Chromate Inhibitors in Engine Cooling Systems.** D. D. Wright. *Can. Chem. and Process Ind.*, 32, 533-535 (1948) June.

Deals with control of corrosion in the cooling water system of compressors. Shows how chromate-treated steam condensate removes all danger of scale formation, removes scales already present in the engine, and increases the expected life of piping employed.—BLR.

**New Inhibitor for Sulphuric and Hydrochloric Acids.** *Wire and Wire Products*, 23, No. 3, 255 (1948) Mar.

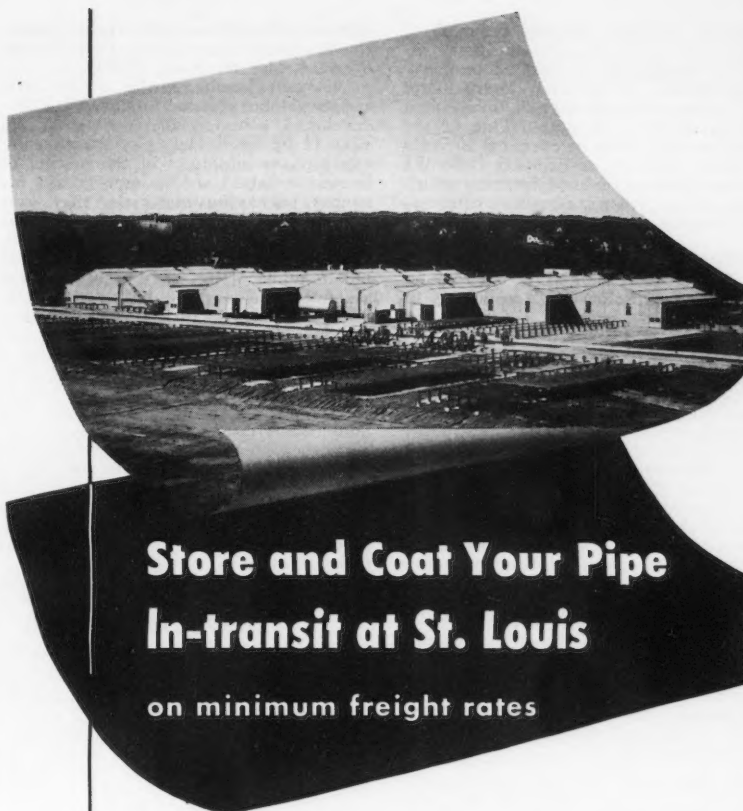
A new liquid inhibitor, Enthone Inhibitor No. 9, which dissolves readily in acid solutions is useful where exhaust ventilation is not available. In solutions of both hydrochloric and sulfuric acid, inhibiting action is from 90-98 percent. Suitable for both cold and hot pickles. Steel coated with scale, oxide, and rust can be pickled without attack on base metal. Bright surfaces are left bright after pickling operations. Announced by Enthone, Inc., New Haven.—INCO.

**The Effects of Inhibitors and Inorganic Matter on the Corrosion of Iron in Warm Water.** (In German.) W. Machu. *Archiv für Metallkunde*, 1, 267-270 (1947) June.

Effects of various inhibitors and oxidants on the solubility of iron in water at 60°C were investigated. Data are charted and tabulated.—BLR.

**Chemical Removal of Scale, Sludges and Oxides from Steel Plant Equipment.** B. H. McDaniel, Dowell, Inc. Paper before AISE Ann. Conv., Cleveland, Oct. 4, 1946. *Iron & Steel Eng.*, 24, No. 9, 43-49 Disc. 49-50 (1947) Sept.

Effective inhibitors allow the use of



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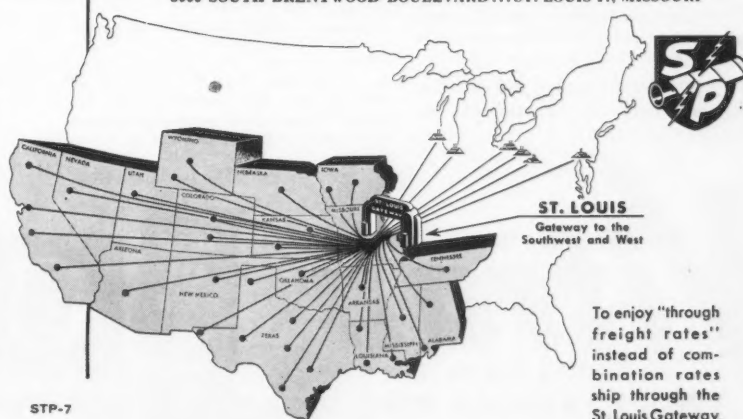
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chemical solvents for the removal of scale and sludge deposits in heavy industrial equipment at elevated temperatures. Effect of inhibited hydrochloric acid compared with that of uninhibited acid is shown in a graph. One of the most beneficial uses of chemical solvents is in the removal of deposits from the cooling systems of blast furnaces which is described. Other applications of chemical cleaning are given.—INCO.

**Effect of the Addition of Amines on the Electrode Potential of Copper in Buffered Acid Solutions.** Norman Hackerman and J. D. Sudbury. *J. Electrochem. Soc.*, 93, No. 5, 191-198 (1948).

The extent of inhibitor adsorption on a metal surface can be followed by observing the change in the electrode potential of that surface, this change depending on the concentration and nature of the inhibitor. The potentials obtained using several amines at several different concentrations were found to fit an equation based on the Langmuir adsorption equation. The slope of the potential-concentration curves decreases as adsorption takes place on the less active regions of the metal surface, following a large potential change due to initial adsorption on the more active parts. It is suggested that while such inhibitors reduce the solution tendency of the active metal spots, nevertheless the total effectiveness of the inhibitor is due to a combination of this decrease with cathodic effects and diffusion control. 14 references.—MA.

**Properties, Naval Uses and Effect on Non-Ferrous Metals of Vapor Phase In-**

**hibitors VPI 220 and 260.** H. R. Baker, U. S. Naval Res. Lab. *Deterioration Abstr.*, 4, Met. 66, A-387 (1948).

Diisopropylamine nitrite (VPI 220) and dicyclohexylamine nitrite (VPI 260) developed commercially during World War II by Shell Dev. Co. are effective vapor phase inhibitors of the rusting of ferrous metals. Used as impregnants for porous packaging materials, they give effective protection of ferrous metals even under severe storage conditions. VPI 220 is effective between -40° and 120°F. while VPI 260 is more effective at temperatures above 120° and equally effective from 32° to 120°. The inhibitor sublimates from the solid state and adsorbs on the metal surface to form a monomolecular hydrophobic film. Due to the low molecular weight of the hydrocarbon portion, prolonged contact with liquid water causes desorption and hence permits rusting. These compounds are used as rust inhibitors in the vapor phase above aqueous solutions such as hydraulic fluids, and in antifreeze solutions containing water with alcohols, glycols, etc. Both nitrites are somewhat corrosive to non-ferrous metals.

given of some of the methods more generally used.—BLR.

**Progress Report on Drill String Research—Non-destructive Testing of Drill Pipe.** R. C. McMaster and H. M. Banta, Battelle Memorial Inst. *Petro. Eng.*, 19, No. 2, 64, 67+ (1947) Nov.

Results of a survey of possible methods for the non-destructive inspection of drill pipe. Seven possible methods for testing new drill pipe in the mill and 10 other methods for testing used drill pipe in the field are given. Supersonic conduction tests, methods involving measurements of conduction through discontinuities, have developed the Sperry Supersonic Reflectoscope. Sketches of possible supersonic transmission and reflection methods for the testing of used drill pipe show those applying one side supersonic detection, and those applying two side supersonic detection. The Du Mond Cyclograph was investigated as a method of testing; a new instrument to supplant the present one is being designed. Tests that reject drill pipe for defects that have no influence on its performance or its operating life are of no value. Further work will be done.—INCO.

**Comparative Tests on Creep of a Ring Specimen in Bending and of a Cylindrical Specimen in Tension.** (In Russian.) I. A. Odging and S. I. Matveyev. *Zavodskaya Laboratoriya* (Factory Laboratory), 14, 595-607 (1948) May.

Proposes, for the creep test, a special type of ring specimen. Shape and dimensions are indicated. Test apparatus, including electrical circuit, is described.

## INSPECTION

**Some Crack Detection Methods.** Horace Manley. *Metallurgia*, 38, 165-168 (1948) July.

Many nondestructive methods have been developed and applied for the detection of internal flaws in ingots, forgings, castings and other metal products, and in this article a brief review is

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and a comparison of the data obtained from such specimens with that from the usual type of specimens is given in graphic and tabular form.—BLR.

## TESTING

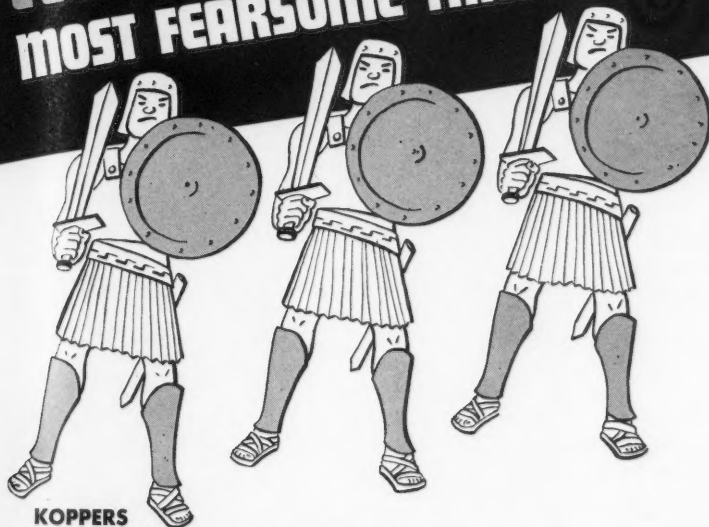
**Corrosion Resistance of Nonferrous Alloys.** *Mat. & Meth.*, 27, No. 4, 112-113 (1948) April.

Accelerated corrosion tests are always open to question until their relationship with actual corrosion in service has been proved. An interesting comparison of the results of short-time water vapor tests at 200°F. (93°C.), weathering tests, total and alternate immersion in artificial sea water and stress corrosion tests is given on a series of zinc alloys

(with 4 percent copper; 4 percent aluminum and 1 percent copper; 32 percent aluminum and 3 percent copper) as well as brass and two aluminum alloys in an article by E. Gebhardt in *Metallforschung*, October 1947.

Gebhardt found there was no quantitative relationship between the results of the water vapor tests and those of the other corrosion tests. For example, in the water vapor tests, the corrosion of high aluminum zinc alloys increased with the amount of lead present. In atmospheric tests, however, as evaluated on the basis of loss of mechanical properties, the lead content (up to 0.8 percent) proved beneficial rather than deleterious. Moreover, the water vapor test proved to be particularly severe for the zinc alloys. This test is considered use-

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ful only as an indication of corrosion resistance under typical conditions.

The rating of the individual alloys in any specific test varied with the method of evaluation. Often the loss in weight, for example, gave an entirely different picture from the loss in tensile or impact properties. The results of the total and alternate immersion tests were on the whole, in agreement.

The effect on corrosion of impurities in the high aluminum-zinc alloys depended on the type of test and means of evaluation. The less pure alloys showed more corrosion in the water vapor test and in the atmospheric test as evaluated on the basis of weight change. The change in elongation and reduction of area, however, in the atmospheric tests were less than for the high purity alloys. In the immersion tests, the high purity alloys were again the least resistant. The heat treatment used to increase the strength of these alloys (water quench) from 650°F. [340°C.] with ageing at 250°F. [121°C.] proved beneficial to the corrosion resistance, with the improvement in some cases more than 70 percent.—ALL.



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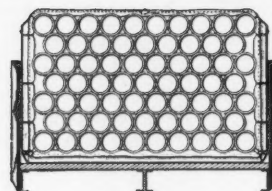
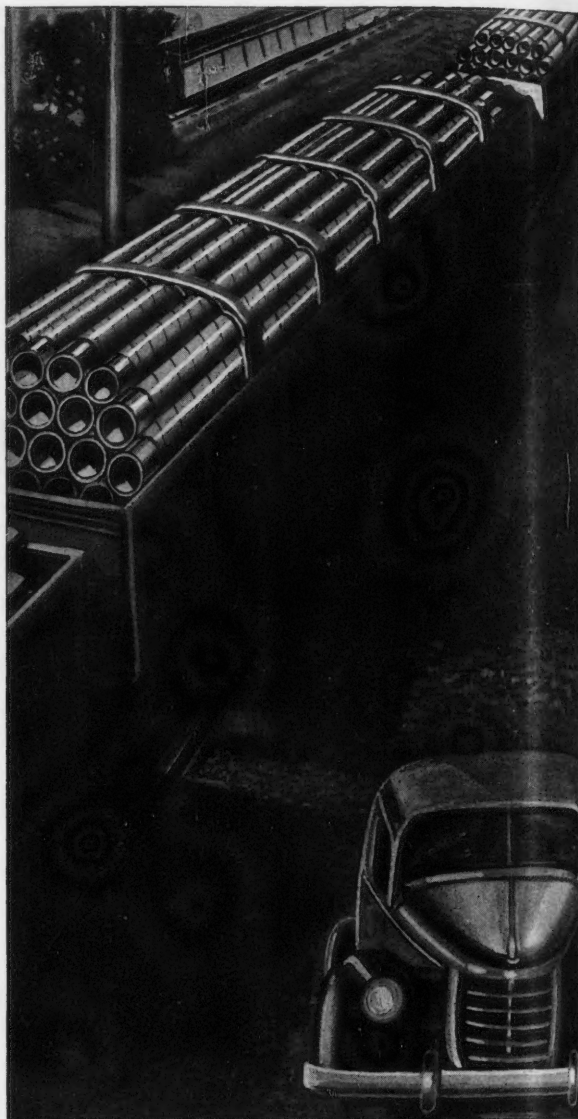
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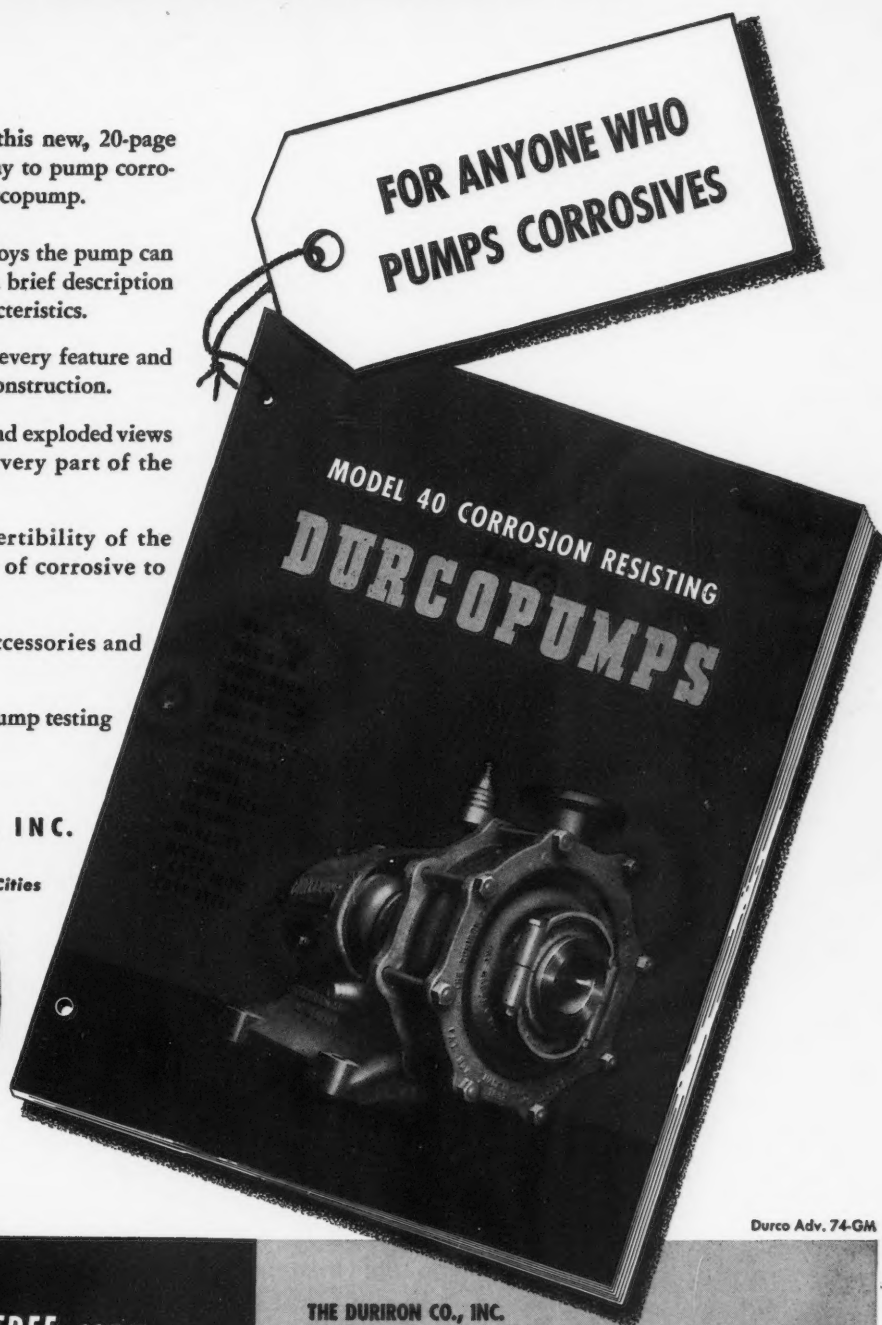
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